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THE ESTIMATION OF LEAN BODY WEIGHT FROM "SKELETAL" MEASUREMENTS

BY ALBERT R. BEHNKE

U. S. Naval Radiological Defense Laboratory
San Francisco 24, California

IT has been established by *in vitro* analysis that the proportions of water, mineral and organic solids are remarkably constant in the adult, fat-free body. In lower animals, specifically in in-bred strains such as the rat, the nearly exact ratio of water to solids in all individuals of the in-bred group allows one to calculate with a high degree of accuracy, from total body water alone, the amount of organic and mineral solids present (Babineau and Pagé, 1955). It is probable also that a fourth entity, the essential lipids chiefly in bone marrow and the central nervous system, constitute a rather uniform percentage by weight of the more inclusive *in vivo* entity, the lean body mass (LBM), (Behnke *et al.*, 1953).

The fat-free body, as well as the lean body mass, may serve as reference bodies. In man, both whole body density and total body water (TBW) determinations permit an estimate to be made, either of fat-

free weight or of the lean body mass. In addition, one may consider the suitability of measurements of bone diameters as a basis for the estimation of skeletal weight and, in turn, lean body mass. It appears that the external size of the skeleton, despite involutional changes in the cortex with age, remains constant throughout the active period of adult life in healthy individuals. In the disease state (not involving bone), particularly in the presence of edema, it would be advantageous (since total body water and density techniques may not reveal the desired information or be feasible) to employ bone measurements, provided that they can be translated into bone or reference body weights.

In a previous paper (Behnke *et al.*, 1959), the body was compared with a cylinder, and girth dimensions, principally, were converted into a "body radius." Thus, R, the body radius for any individual, was obtained from D (the anthropometric dimensions) divided by a constant (k). Body weight was calculated from $\pi R^2 h$, h representing stature in decimeters. In this paper the same type of analysis will be applied to skeletal dimensions in an effort to translate "skeletal" measurements into their LBW equivalents in much the same manner as the "envelope" measurements and stature were used to compute gross body weight. In this connection, one may consider the intermediate step involved in the estimates of the weight of the skeleton itself from anthropometric measurements. Matiegka (1921) stated that skeletal weight could be determined from 8 transverse diameters ($8TD$) measured by means of calipers applied to the condyles of the femur and humerus, and at the wrists and ankles. His formula is an expression of the basic principle underlying our analyses, namely

$$\text{Bone weight (gm)} = \left(\frac{8TD}{n}\right)^2 \times h \times k$$

in which h is stature in cm, and the constant k was presumed to lie in the range of 1 to 1.2. It was "to be determined subsequently." However, although Matiegka's supporting data were inadequate, it can be shown that skeletal weights calculated from his formula are supported by estimates of skeletal size obtained by indirect methods and by the occasional direct analysis.

Trotter (1954) made the measurements suggested by Matiegka, as well as measurements from roentgenograms, of the area of the femur and of the compact bone in the middle half of the femur on 24 white male skeletons. Subsequently Merz, Peterson and Trotter (1956) examined some 200 skeletons and developed equations for the estimation of the

weight of the skeleton from x-ray visualization of the femur shaft. For our purpose, the value of this material is somewhat limited by the fact that the bones were degreased by exposure to fumes of benzol to remove most of the fat and also water by drying. Hence, the weight of the fresh bone is not known. Further, the skeletons were chiefly from older individuals (average age 55, range 18 to 87 years). However, from an analysis of Trotter's data, it was apparent that a reasonably good correlation ($r = .89$) existed between skeletal diameters (Matiegka) and the planimeter x-ray area of the femur. The area of compact bone of the middle third of the femur, together with stature, showed the highest correlation with actual bone weight, in Trotter's analysis, $r = \sim .82$. The highest correlation, $r = .96$, was found between the weight of the femur and the weight of the entire skeleton. These relationships make possible helpful deductions as to skeletal size from the characteristics of a single bone which can be studied in its entirety on the x-ray film.

Estimates of body weight from bone dimensions. Willoughby (1932) recorded certain "skeletal" dimensions on a selected group of athletic young men, and also on young women, as did Turner (1943) on college girls, from which they calculated "optimal" weights. The measurements were mainly diameters, *i.e.*, biacromial, chest, bi-iliac, and bitrochanteric, but included also circumferences of the wrist and ankle. To these measurements, we have added diameters of the knee, wrist and ankle.

In this paper are reported the results of anthropometric "skeletal" measurements and those also of the trunk and extremities (Matiegka's 8*TD*), utilizing in this case an x-ray technique.

PROCEDURES

The volume of the body was determined in a sealed chamber by the helium dilution technique (Siri, 1956). Siri's equation for estimating the percentage of fat from density alone is: $\%\,\text{fat} = \frac{495.0}{\text{density}} - 450.0$. In this equation, the constants for the density of the fat-free body and of pure fat are 1.100 and 0.90 respectively.

Total body water was determined as the "tritium" space using tritiated water which was taken by mouth. Samples of urine were collected subsequently after equilibrium had been established between the tritiated water and body fluids. The standard error of estimate in replicate analyses by this technique is $\pm 2\%$ of the body water measured.

The weight of the fat-free body may be estimated from total body water (kg), substituted in the following expression:

$$\text{F-FB} = 100\left(\frac{\text{TBW}}{72}\right).$$

The combined equation (Siri) incorporating both body density and percent body water for the estimation of the percentage of fat in the body is:

$$\%\ \text{fat} = \frac{213.66}{\text{density}} - 77.49\left(\%\ \frac{\text{TBW}}{\text{weight}}\right) - 137.4.$$

This equation essentially permits an estimate of fat to be made from body density in which the double component system comprises fat and the fat-free mass minus the separately analyzed body water. From theoretical considerations, the standard error of estimate when body fat is calculated from either density or TBW alone can be shown to be of the order of $\pm 4\%$ of body weight. This is reduced to $\pm 2\%$ if the calculation of body fat is made from both TBW and density, as in the combined Siri equation.

Anthropometric measurements (31 subjects).

The technique employed was essentially that outlined by Hertzberg and Daniels (1954). A broad blade (Hrdlička) anthropometer was employed for the measurement of chest width only; all other diameters were measured with a narrow blade (Martin) anthropometer. A pliable plastic tape was used for girth measurements of the wrist, ankle, and knee. The details of the measurements follow, since the data pertain only to the anatomical locations selected, and the procedure as outlined.

With the subject in the sitting position, arms at the sides and forearms (palms down) resting on the legs, the following measurements are made: 1) biacromial width, the distance between the most lateral projections of the acromial processes (observer standing behind the subject); 2) knee-to-knee width, the maximal horizontal distance between the lateral surfaces of the knees in contact; 3) knee width, the distance between the apex of head of fibula and the median condyle of the tibia.

With the subject standing, feet together: 4) chest width, level of the nipple line and with the breath held at the mid-point of a *normal* tidal volume excursion (moderate pressure is exerted on the broad blade anthropometer); 5) bi-iliac width, maximal diameter between iliac crests,

pressure is applied to the blades of the anthropometer to feel bone resistance of the cristal borders; 6) bitrochanteric width, maximal diameter between the greater trochanters with pressure applied to the narrow blades of the anthropometer; 7) wrist width, distance between styloid processes of radius and ulna; 8) wrist circumference, minimal girth measured *proximal* to the styloid process of the ulna.

With the subject standing on a bench: 9) ankle width, distance between malcoli with the bar of the sliding caliper held perpendicular to the long axis of the foot; 10) ankle circumference, minimal leg girth above malcoli; 11) knee circumference, with the knee slightly flexed, the tape is drawn across the middle of the patella.

Paired right and left side measurements are made on the extremities and the average recorded.

X-ray technique (*22 subjects*).

a. Extremities (figure 1). The radiographs were made with standard technique, being careful to center the tube vertically above the middle of the part. The distance, tube to table top, was about 40 inches. Instead of calculating the magnification, a lead ruler, notched at 5 cm intervals, was laid on a wood block alongside the part half-way between upper and under surfaces. When a Bucky diaphragm was used, the correction approached 10%. It was convenient to take both knees on one end of a large film and both ankles on the other. The feet should be tied together to prevent foreshortening by external rotation. Similarly, both elbows and both wrists were taken on one film.

b. Trunk. The chest and the pelvis were taken at 6 ft. distance, with subject standing, facing the tube. The lead ruler was on a stand at his side, halfway between front and back. The subject held his breath with lungs about half full.

The diameters and their end-points were inscribed on the film (figure 1), and then measured to the nearest half millimeter, using dividers and millimeter scale.

Since we have become more careful to avoid unnecessary x-ray exposure, we now recommend that the pelvis be taken with subject supine, using a 14×17 inch film transversely at about 40-inch tube distance. With a long cone to cover a 4 or 5 inch circle, the tube is brought over one iliac crest and then over the other, the two exposures being made on one film. This gives a record without magnification. The gonads receive only a negligible exposure, being outside the useful beam. There

is no need to use such a technique on the chest, for the gonads are outside the beam.

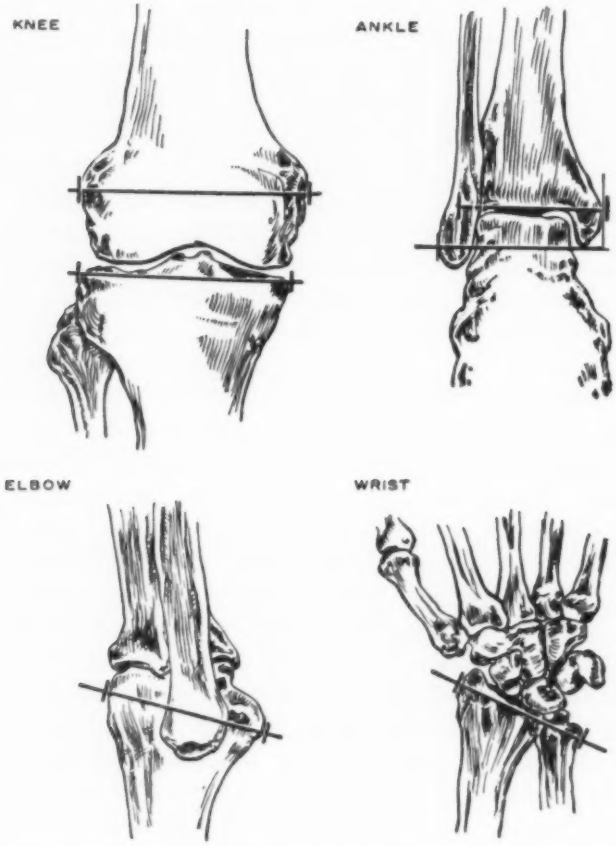

FIG. 1. SITES OF MEASUREMENTS ON X-RAY FILM OF DIAMETERS OF DISTAL ENDS OF LONG BONES (*8TD*) AND OF THE PROXIMAL AND DISTAL ENDS OF THE TIBIA. THE BI-MALLEOLAR DIAMETER IS MEASURED ON A HORIZONTAL PLANE AS INDICATED.

DERIVATION OF CONSTANTS FROM GROUP DATA

The 31 subjects were selected so as to provide a wide range of statures and gross weights. This is reflected in the high coefficients of variation (C. V.) for stature (4.9%) and for weight (18.1%) compared with the C. V. values for the same parameters in the group of Hertzberg and Daniels (1954), table 1. The mean body weight for the Navy group

of 31 men was 78.3 kg, and mean stature, 17.83 dm. The mean group value for fat-free weight calculated from Siri's combined equation was 61.6 kg, which was slightly less than the median value of 62.9 kg.

TABLE 1

Mean values (cm) for stature, "skeletal" diameters and circumferences of the ankle and wrist of young men

GROUP	STATURE	WEIGHT	BIACROM.	CHEST	BI-ILIAC	KNEE-TO BITROCH.	KNEE	ANKLE	WRIST
Navy* ($N = 31$)	178.3	78.3	40.6	29.9	29.4	32.8	20.5	22.5	17.2
C.V.	4.9	18.1	4.6	6.5	7.8	6.9	5.2	5.6	5.0
Air Force** ($N = 4000$)	175.5	74.4	40.0	30.6	—	33.5	20.1	22.7	17.4
C.V.	3.5	12.7	4.7	6.7	—	5.5	6.6	6.4	5.8
Athletes*** ($N = 50$)	175.3	76.2	40.9	30.5	28.4	32.8	—	22.4	18.0

Additional Measurements: (Navy)
Knee W (9.2), Knee C (38.3), Wrist W (5.59), Ankle W (6.94)

Sources: *Behnke (this report), **Hertzberg and Daniels (1954), ***Willoughby (1932).

If lean body weight contains an additional 3% essential fat, then the mean lean body weight $\overline{(\text{LBW})}$ for the Navy group may be estimated as 63.4 kg. The mean radius of the lean body mass, $\bar{R}$ (LBW), was derived from substitutions in the formula

$$R(\text{LBW}) = \sqrt{\frac{\overline{\text{LBW}}}{\pi h}} = \sqrt{\frac{63.4}{\pi 17.83}} = 1.064 \text{ dm.}$$

Dividing the mean group "skeletal" measurements by 1.064, one obtains the "k" values listed in table 2. The calculation of lean body weights of subjects 2 and 4 is presented also in this table. Thus, the radius of the lean body mass for any individual, $R(\text{LBW})$, is calculated from the ratio, $\frac{\text{Skel I}}{k}$. The value of k for this combination of measurements is 181, and this is the sum of the "k" values for the single dimensions in table 2. LBW for the individual is then calculated from $\pi R^2(\text{LBW})h$, where h is the individual's stature in decimeters. The dimensions listed in table 2 are designated Skel I. With the exception of chest width and

TABLE 2

Derivation of Navy group constants ("k" values) for the calculation of lean body weights from anthropometric dimensions and application of these constants to data on two subjects of different build

NAVY GROUP ($N = 31$) Stature (h) = 17.83 dm			SUBJECT 2 $h = 17.88$ dm			SUBJECT 4 $h = 18.03$ dm		
DIMENSIONS (D) (Skel I)	D (Mean Values)	"k" Values $D \div 1.064$	D	Single "R" Values $D \div$ "k"	% dev. from R(LBW)	D	Single "R" Values $D \div$ "k"	% dev. from R(LBW)
Diameters	cm		cm	dm		cm	dm	
biacrom.	40.6	38.2	42.1	1.102	−3.3	41.8	1.094	−3.4
chest	29.9	28.1	32.3	1.149	+0.8	32.7	1.164	+2.7
bi-iliac	29.4	27.6	31.5	1.141	+0.1	33.6	1.217	+7.4
bitroch.	32.8	30.8	34.8	1.130	−0.9	34.6	1.177	+3.9
knee-to-knee	20.5	18.9	22.4	1.185	+3.9	20.3	1.074	−5.2
Circumferences								
wrist	17.2	16.2	19.4	1.198	+5.1	16.6	1.025	−9.5
ankle	22.5	21.1	23.8	1.128	−1.1	25.6	1.213	+7.1
Σ	192.9	180.9	206.3			205.2		
$k = 180.9$ (~ 181)								
$\bar{R}$(LBW) = 1.064			$R(\text{LBW}) = \frac{206.3}{181} = 1.140$			$R(\text{LBW}) = \frac{205.2}{181} = 1.133$		
LBW (median) = $\pi\bar{R}^2(\text{LBW})h = 63.4$			LBW = $\pi R^2(\text{LBW})h = 73.0$			LBW = $\pi R^2(\text{LBW})h = 72.7$		

the substitution of knee girth for the diameter of both knees, these dimensions have been employed extensively by Turner (1943) for the calculation of "optimal" weights of college girls.

TABLE 3

Derivation of x-ray "skeletal" dimensional values and dimensional (lean body weight) constant (k) for a military reference man from Navy (roentgenogram) measurements, and cadaver bone anthropometry

	DATA SOURCE				
			Anthropometric		
		X-ray	Disarticulated Male		
Dimensions (cm)		Navy Men	Skeletons		
"8 transverse diameters" ($8TD$)†		$N = 22$*	$N = 38$**	$N = 20$***	REFERENCE MAN
	R(dm)	1.064	1.071	1.055	1.063	$k(D(\text{cm})) \div R$
Elbows		12.8	13.2	"8 transverse diameters"	12.93	12.16
Wrists		9.8	9.9		9.90	9.31
Knees		17.2	17.7		17.39	16.36
Ankles		12.8	13.1		12.93	12.16
$\Sigma 8TD$		52.6	53.9	53.0	53.15	
$k = \Sigma 8TD \div R$		49.0	50.4	50.2	50.0	49.99
Tibia (intercondyles)		15.8	16.4	—	15.96	15.01
Tibia (distal end)		11.0	11.4	—	11.11	10.45
Age		29 (20-53)	29 (19-42)	55 (18-87)		
Stature dm		17.77	17.63	17.15		17.40
$\bar{m}$ Weight kg		78.3	75.1	—		70.0
LBW ($\pi R^2 h$)		63.4	63.4	60.0		61.8
LBW (median value) =◊=		$0.201\bar{m}h^2$	$0.204\bar{m}h^2$	$0.204\bar{m}h^2$		$0.204\bar{m}h^2$

† Elbow, knee (bicondylar: humeral, femoral diam.); wrist (radial-ulnar styloid diam.); ankle (bi-malleolar diam.).

Sources: *Behnke (this report), **Garrison (1957), ***Trotter (1954).

Another combination of measurements was also selected so that the trunk and extremities would have approximately equal weighting in the computation of lean body weight. These have been designated Skel II and, in addition to the biacromial, chest, and bitrochanteric diameters, include the following combinations of dimensions for which the "k" values are given in parentheses: bi-knee diameter plus the average of

the right and left knee diameters (28.7), the ankle circumference plus the average of the right and left ankle diameters (27.7), and the wrist circumference plus the right and left wrist diameters (25.7). The summated "k" values for the Skel II group are equal to 179.2, rounded to 179 for the calculation of individual weights.

Constants for the diameters of single dimensions not previously given are: knee (8.66), wrist (5.31), ankle (6.52), and for the circumference of the knee, 36. The mean group value in centimeters for any dimension or combination of dimensions is obtained from the product of the "k" value and mean group radius, 1.064.

Derivation of constants for the x-ray film measurements.

The mean group values for measurements of the "8 transverse diameters" (8*TD*) from roentgenograms are listed in table 3. Included in this table also are the anthropometric measurements of Trotter (1954) of the 8 transverse diameters shown in figure 1. The technique used by Garrison (1957) was the same as that described in this report. It is seen from the table that the summated "k" values ($\sim$ 50.0) are nearly the same for the three groups and serve to define the relationships for the Reference Man. The derivation of median values for lean body weights for the Garrison and Trotter data will be discussed in a subsequent paragraph. In addition to the constants applicable to the extremity diameters, there may be added the constants obtained from roentgenograms for the lateral diameter of the chest (26.22), the bi-iliac diameter (25.94), and the bitrochanteric diameter (28.28). The actual mean values in centimeters for these dimensions may be calculated from the product $k \times 1.064$.

ANALYSIS OF DATA

Fat-free body weight.

As previously stated, the mean value of fat-free weight (F-FW) for the 31 men, calculated from both density and TBW determinations (Siri combined equation) was 61.6 kg. The F-FW computed from density alone was 60.1 kg, and from TBW, 63.8 kg. These mean values are only slightly altered when the group size is reduced to 22 men (table 4). The mean value for TBW of 46.0 kg is 76.5% of the fat-free body weight calculated from the density values. This is considerably higher than the values of 72 to 73% obtained on other groups of men (Osserman *et al.*, 1950), and from analyses of animal carcasses (Babineau and Pagé).

TABLE 4

Lean body weight (LBW) in kg, estimated from body density, water determinations, and from x-ray and anthropometric measurements ($\pi R^2 h$)

				X-RAY	ANTHROPOMETRIC DIAMETERS							FAT-FREE WEIGHT from	
SUBJECT	AGE	STATURE	WEIGHT KG.	$8TD$	Chest W Bi-iliac Bitroch.	Chest W Bi-iliac Bitroch.	Chest Biacrom. Bitroch.	Wrist Ankle Knee	SKEL. I	SKEL. II	LBW	Total Body Water	Body Density
1	34	20.15	117.5	87.9	—	91.3	88.0	89.0	87.7	88.2	77.3	75.7	76.0
2	52	17.88	100.0	70.6	71.7	73.5	71.7	77.7	73.0	73.6	70.4	68.9	70.8
22	48	17.75	100.0	71.4	—	77.8	78.5	71.5	75.5	74.4	74.8	80.0	64.7
4	31	18.03	98.9	62.3	65.7	77.5	71.5	58.9	72.7	68.2	65.0	67.1	61.2
13	39	18.80	98.4	76.0	77.2	80.2	76.5	71.9	76.4	75.5	75.1	74.3	72.8
21	21	17.75	77.0	66.3	71.6	68.3	67.3	68.1	66.1	66.9	66.5	70.3	60.2
24	31	19.35	83.9	74.2	75.0	72.0	71.4	71.1	72.9	73.3	69.4	67.1	67.0
20	31	17.73	75.9	58.4	64.4	59.3	58.0	60.9	58.0	57.9	64.9	66.7	60.6
3	21	17.93	67.7	62.7	70.2	66.2	64.4	64.0	63.8	62.9	64.3	62.9	62.9
20	20	16.20	61.1	53.8	52.6	50.4	52.2	52.2	52.6	52.7	51.6	50.4	51.5
17	20	16.10	54.8	48.4	47.5	44.7	47.8	47.8	47.7	49.5	49.5	47.6	50.5
28	23	17.18	52.4	53.5	51.4	47.0	48.1	49.7	48.7	49.3	46.7	45.0	46.7
$\bar{M}$				65.4	—	67.3	66.3	65.2	66.3	66.0	64.6	64.7	62.8
$\bar{M}$ ($N = 22$)				63.7	—	—	63.4	63.4	63.4	63.6	63.4	64.4	60.9
C. V.				11.8	—	—	12.7	12.3	12.8	11.7	12.2	14.7	11.5

LBW = Fat-free weight ÷ 0.97. Fat-free weight is calculated from TBW and density in Siri's equation.

The differences between F-FW calculated from density and from body water alone are in some individuals exceptionally large, *e.g.*, in subject 22 it amounted to 15.3 kg. If the gross fat-free components of the body, such as water, constitute constant percentages of F-FW, the densitometric and TBW determinations of F-FW should agree. In this group study the variability expressed as the standard error of the differences between the two sets of values is $\pm$ 8.2% of the mean lean body weight, *i.e.*, $\sim$ 5 kg. The data (table 4) serve to emphasize the rationale not only of carrying out both density and TBW determinations, but the need to ascertain additional body components, such as exchangeable chloride and potassium in order to resolve the discrepancy between the TBW and density determinations of fat-free weight in some individuals. If the healthy adult fat-free body contains variable percentages of water in different individuals, then the premise underlying our estimates of LBW from skeletal dimensions is not rigidly valid.

Lean body weights calculated from "skeletal" measurements (table 4, fig. 2).

The following tabulation gives the correlation coefficients and the standard errors of estimate (V) expressed as percentages referable to the mean LBW of 63.4 kg.

Dimensions	X-ray	Diameters		$R(e)+R(t)$	SKEL I	SKEL II
	8 *TD*	wrist, knee, ankle	biacrom., chest, bitroch.			
		$R(e)$	$R(t)$			
r	.81	.84	.84	.89	.83	.84
V	10.1	9.4	6.8	6.0	9.2	7.0

The most unsatisfactory group of measurements are those which include the bi-iliac diameter. Unusually large discrepancies in some individuals characterize this measurement as revealed by a comparison of anthropometric and roentgenogram data. Variations in the amount of excess fat could account for the largest error in the measurements.

Effect of subcutaneous fat on the anthropometric measurements.

The effect of dietary induced weight loss on subcutaneous fat is reflected in the changes recorded in connection with measurements made

on subject 2 (table 5). The Skel II data are less sensitive than are the Skel I values. The desired precision in technique can be made only if the diameter measurements are corrected for thickness of tissue over the bone landmarks.

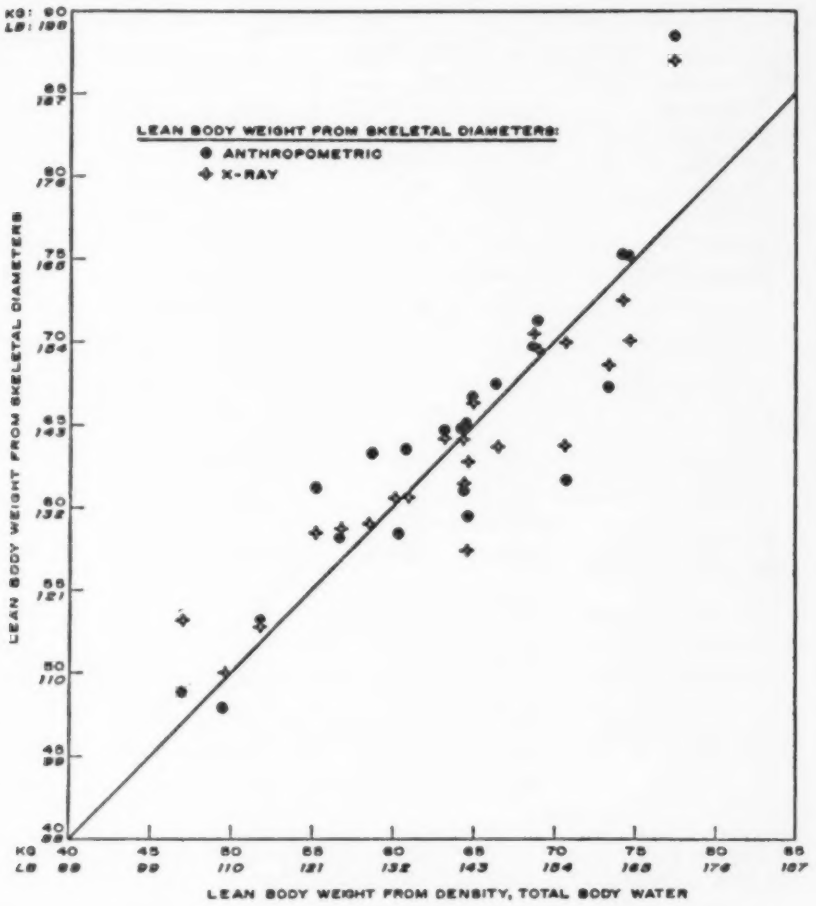
LEAN BODY WEIGHT FROM SKELETAL DIAMETERS:
ANTHROPOMETRIC
X-RAY
LEAN BODY WEIGHT FROM SKELETAL DIAMETERS
LEAN BODY WEIGHT FROM DENSITY, TOTAL BODY WATER

FIG. 2. A COMPARISON OF INDIVIDUAL LEAN BODY WEIGHTS (LBW) CALCULATED FROM ANTHROPOMETRIC "SKELETAL" DIMENSIONS WITH LBW BASED UPON DENSITY AND TOTAL BODY WATER ANALYSES. THE BONE DIMENSIONS MEASURED WITH THE ANTHROPOMETER ARE CHEST W, BIACROMIAL, BITROCHANTERIC, WRIST, KNEE AND ANKLE DIAMETERS. THE DIAMETERS MEASURED ON THE X-RAY FILMS ARE THE 8 TRANSVERSE DIAMETERS OF LONG BONES.

TABLE 5

Successive "skeletal" measurements of subject 2 during a period of voluntary weight (kg) reduction

	1955		1956		
	Sept	Feb	Mar	June 8	June 22
SKEL I					
Biacromial	42.1	41.7	41.3	41.4	41.4
Chest W	32.3	31.4	31.1	31.4	30.9
Bi-iliac	31.5	31.1	30.5	31.4	30.3
Bitroch.	34.8	35.1	34.1	34.2	34.1
Ankle	23.8	23.7	23.3	23.3	23.3
Wrist	19.4	19.1	18.9	19.1	19.2
Knee-to-knee	22.4	21.9	21.8	21.4	21.6
	206.3	204.0	200.9	202.2	200.8
Calc. LBW*	73.0	71.3	69.2	70.1	69.1
Body Weight	100.0	91.6	86.3	86.4	83.6
SKEL II					
Biacromial	42.1	41.7	41.3	41.4	41.4
Chest W	32.3	31.4	31.1	31.4	30.9
Bitroch.	34.8	35.1	34.1	34.2	34.1
Knee-to-knee / Av. R & L Knee W	33.1	32.5	32.0	31.4	31.9
Ankle C / Av. R & L Ankle W	31.1	31.0	30.8	30.8	30.7
Wrist C / R + L Wrist W	31.6	31.8	31.4	31.5	31.9
	205.0	203.5	200.7	200.7	200.9
LBW**	73.6	72.6	70.6	70.7	70.7
W	100.0	91.6	86.3	86.4	83.6

* $\text{LBW} = \left(\frac{\text{Skel I}}{181}\right)^2 \pi h$ ** $\text{LBW} = \left(\frac{\text{Skel II}}{179}\right)^2 \pi h$, $h = 17.88$ dm.

Variability of intra-individual "skeletal" measurements.

Intra-individual variation of radii calculated from single dimensions relative to the radius of the LBM is evident from data in table 2. Thus, the trunk dimensions of subject 4 are relatively larger than his extremity dimensions and the inverse pertains to subject 2. Similar differences in girth dimensions were reported also for these subjects (Behnke *et al.*, 1959).

The standard deviations of the differences between a radius calculated from any single dimension and the radius of the lean body mass computed from the summated dimensions are given by the following (±) values: diameters; biacromial (2.87), chest (3.04), bitrochanteric (2.70), knee-to-knee (3.16) and circumferences: ankle (3.62) and wrist (2.51).

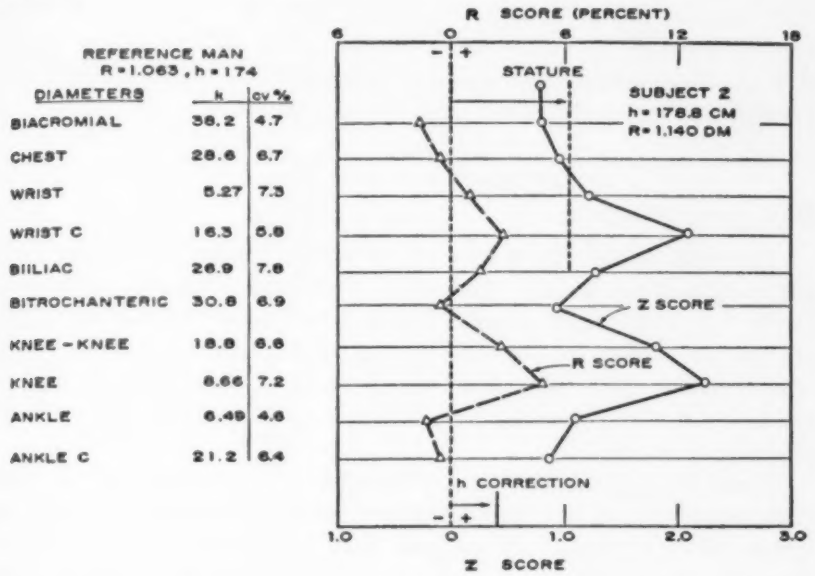

FIG. 3. "SKELETAL" PROFILE OF A SUBJECT IN TERMS OF THE "Z" SCORE $\frac{X-\bar{M}}{\sigma}$ AND THE "R" SCORE [% DEVIATION FROM THE INDIVIDUAL'S LEAN BODY RADIUS (R(LBW))]. THE STATURE (h) CORRECTION IS REFERABLE TO THE DIFFERENCE BETWEEN THE SUBJECT'S STATURE (178.8 CM) AND THE REFERENCE STATURE (174 CM).

Graphical representation of lean body size.

The intra-individual variations in the skeletal measurements may be presented diagrammatically in terms of a "Z" score (Garn, 1955), or an "R" score, figure 3. The "Z" score for each dimension is computed from $Z = \frac{X - \bar{M}}{\sigma}$. It is thus the ratio of the distance from the group mean ($\bar{M}$) of the individual measurement (X), to the standard deviation (σ) of the group "X" values. The correction for stature, h (fig. 3) in connection with the "Z" score is required to adjust for the difference

between the $\bar{M}$ values for the Reference Man ($h = 174$ cm) and those of the subject ($h = 178.8$ cm). In this case, the h correction is subtracted from "Z" scores of the figure.

The "R" score is the percentage deviation of any single dimension R from the individual's LBM radius (R(LBW)). If a rounded number of 6% is used as the CV for all dimensions except stature, then the "R" score is a convenient measure of intra-individual variation. For a comparison of the individual's position with respect to the group, it would be necessary to compare individual R(LBW), (for subject 2, 1.140) with group $\bar{R}$(LBW) adjusted for stature.

REFERENCE MAN AND WOMAN

Mean group values.

The mean values (table 1) of the "skeletal" measurements on three groups of men are in good agreement. Attention is invited particularly to the "skeletal" dimensions of Willoughby's muscular athletes which are similar to those of the other two groups. This was not true with respect to the girth dimensions, particularly of the upper extremities which reflected the muscular hypertrophy characteristic of weight lifters (Behnke *et al.*, 1959).

From density and body water analyses over a period of 15 years (Behnke, 1953), it has been possible to derive a relationship between stature and mean or median lean body weight for groups of men arranged according to stature, *i.e.*, mean LBW $= 0.204h^2$(dm). Strictly, the squared value of stature should predict a median (not a mean) weight value, but the difference between mean and median values with respect to lean body weight will not make any appreciable difference in the calculations. A mean value of ~ 63 kg is obtained as the calculated value for several groups of men whose mean stature approximates 17.5 dm. The mean stature of the cadavers from which the skeletons were obtained in Trotter's study was 17.15 dm, and the calculated LBW derived from this stature is 60 kg (table 3).

With reference to women, there are no experimental data for fat-free or lean body weights comparable to those for men. If, however, the Skel I conversion constant for men, *i.e.*, $k = \sim 181$, is also applicable to women (as were the "envelope" constants relating circumferential dimensions to body weight), then it is possible to calculate $\bar{R}$(LBW) for women. Thus, for Willoughby's female group (mean stature, 16.27 dm, "skeletal" $\Sigma D = 175.5$ cm), the quotient $175.5 \div 181$ is

0.97 dm. This is an approximation of $\bar{R}$(LBW) applicable to this group of women. Likewise, from Turner's data a value of 0.96 dm ($\bar{R}$(LBW)) was obtained for a group of college girls whose mean stature was 16.45 dm. From πR^2h, their median LBW is 47.6 kg. From the values

TABLE 6

"Skeletal" measurements and the dimensional (lean body weight) proportionality constants (k) for a Reference Man and Woman

DIMENSIONS D (cm)	REFERENCE MAN $R = 1.063$ dm*		REFERENCE WOMAN $R = 0.970$ dm**	
	D	$k = (D \div R)$	D	$k = (D \div R)$
Diameters				
Bitroch.	32.7	30.8	32.0	33.0
Biacrom.	40.6	38.2	35.0	36.1
Chest	30.4	28.6	25.5	26.3
Knee-to-knee	20.0	18.8	18.6	19.2
Bi-iliac	28.6	26.9	28.6	29.5
Circumferences				
Wrist	17.3	16.3	15.2	15.7
Ankle	22.5	21.2	20.6	21.2
Σ	192.1	180.8	Σ 175.5	180.8
GROUP DATA				
Age	20 to 25		18 to 25	
Stature (dm)	17.40 (68.5 in)		16.38 (64.5 in)	
Weight (kg)				
median	69.3 (152.5 lb)		56.4 (124 lb)	
mean	70.0 (154.0 lb)		56.8 (125 lb)	

* "Radius" of LBM

$\pi R^2h = 61.8$ (median LBW) $\simeq 0.204\ h^3$

** "Radius" of LBM

$\pi R^2h = 48.4$ (median LBW) $\simeq 0.18\ h^3$

of lean body weights calculated for the several groups, it was possible to derive the mean body radius for each group and, in turn, to compute the "k" values from the mean group dimensional data. The results were so consistent that it appeared justified at this time to compute constants and dimensions of a Reference Man and Woman, table 6.

Complementary relationships.

The employment of the identical conversion constant (k) for men and women implies that there exists also for the "skeletal" dimensions the same complementary relationships postulated for the girth measurements (Behnke *et al.*, 1959). With respect to the following combinations of anthropometric diameters at least, the "k" values based on the various group data referred to are equal:

$$\frac{k(1)\ \begin{cases}\text{Men}\\ \text{Biacromial}\\ \text{Chest}\end{cases}}{k(2)\ \begin{cases}\text{Men}\\ \text{Bi-iliac}\\ \text{Bitrochanteric}\end{cases}} = \frac{\begin{cases}\text{Women}\\ \text{Bi-iliac}\\ \text{Bitrochanteric}\end{cases}\ k(2)}{\begin{cases}\text{Women}\\ \text{Biacromial}\\ \text{Chest}\end{cases}\ k(1)}.$$

THE SKELETAL MASS AND LEAN BODY WEIGT

We may examine further the applicability of Matiegka's formula for the calculation of bone weight. In this formula, the value of the constant (k), "to be subsequently determined" was postulated to be in the range of 1 to 1.2. The median value of LBW of the cadavers from which the skeletons were obtained in Trotter's study was estimated to be $\sim$60 kg. If fat-free bone weight is $\sim$12% LBW, then mean bone weight = $\sim$7200 gm. Substituting the mean values for the 8 transverse diameters measured on the disarticulated skeletons in Matiegka's formula and with k equal to 1, one obtains a calculated value for bone weight of 7547 gm.

The 8*TD* in the Navy group (Behnke) measured on the radiographs was 52.6 cm, and the mean stature of the 22 men, 17.77 dm. Again, substituting these values in Matiegka's formula, if $k = 1.0$, one obtains a value for bone weight of 7682 gm and

$$\text{LBW} = \frac{100}{12} \times \text{BW} = 64\ \text{kg}.$$

Gross composition of the skeleton.

The percentages by weight obtained by Forbes *et al.* (1953) in an analysis of one entire skeleton were: moisture (28), ether-extractable substance (25), and bone solids (47).

The ash weight in per cent of fat-free dry weight reported by Trotter and Peterson (1955) in an analysis of 6 complete skeletons was consistently close to 65% of fat-free dry weight. From these two sets of

analyses, the relative percentages of the gross components of *fat-free bone* are: water (37), organic matter (22), the mineral substance (41). The mean value of fat-free *dry* bone for the skeletons of Trotter's series ($N = 24$) was 4460 gm. The wet bone weight, applying the above stated percentages, may be calculated as $\frac{100}{63} \times 4460 = 7080$ gm, approximately 11.8% of 60 kg, the calculated LBW.

CONCLUDING COMMENT

The constant, π, can be eliminated from the formulas in the calculation of lean body weight from dimensional values. With stature (h), and the following combination of diameters expressed in decimeters, the simplified formulas for the calculation of LBW (men) are:

Anthropometric Diameters

1. Chest, bitrochanteric, knees, ankles, wrists
   LBW (gm) $= 31.53D^2h$
2. Biacromial, chest, bitrochanteric, knees, ankles, wrists
   LBW (gm) $= 16.52D^2h$

X-ray

3. 8 transverse diameters (fig. 1)
   LBW (kg) $= 0.123D^2h$
4. $8TD$ plus chest, bitrochanteric diameters
   LBW (kg) $= 0.0287D^2h$.

Hechter (1959) has made an independent analysis of the data reported in this paper. As few as three dimensions (*e. g.*, wrist, chest, and stature) can be employed to estimate LBW. For a more complete description of the body, however, and to outline body configuration, the additional measurements are required, even though they contribute little to the accuracy of the LBW calculation.

The ratio of mean LBW for men and women of comparable stature, *i. e.*, 17.4 dm (male) and 16.4 dm (female) cannot be too far from 4 to 3. In this connection, attention is invited to the mean value of 44.6 kg for fat-free weight of women, reported by Garn (1957). His data were based upon an analysis of measurements of fat-plus-skin thickness as revealed by soft-tissue x-rays.

Another approach to the problem is the calculation of lean body weight from mean values of basal metabolism of men and women (Behnke, 1953). If 73.7 Calories per hour (1770 Cal/24 hr) is the basal heat production of young men whose $\bar{M}$ LBW is 63 kg, then the heat production per kg of LBW is 1.17 Cal per hour. Mean basal heat production values for young women have been recorded as 56.3 Cal per hour (1350 Cal/24 hr). If the metabolism per unit of lean tissue is the same in men and women, then the mean lean weight calculated from metabolism is $\sim$ 48 kg.

SUMMARY

1. A comparison was made of lean body weight (LBW) estimated from "skeletal" (anthropometric and "x-ray") measurements and from body density and total body water determinations on 31 male subjects.

2. The correlation coefficients (r) pertaining to this comparison were in the range of 0.80 to 0.90 (S. E. of estimate, 6 to 10% of the mean LBW, 63.4 kg).

3. The higher correlations were obtained when both trunk and extremity dimensions (D) were employed in the calculations which were based on the general formulation, $LBW = D^2kh$, where h is stature.

4. Variations in the amount of subcutaneous fat appear to be responsible for the largest source of error in estimates of LBW from the anthropometric measurements.

5. The x-ray technique for measurements of joint diameters (Matiegka's 8 Transverse Diameters) is satisfactory, but these measurements alone ($r = 0.80$) are not as highly correlated with LBW as are the combined trunk and extremity diameters.

6. The translation of "skeletal" dimensions into body radii, analogous to the dimensions of a cylinder, facilitates the comparison of an individual's dimensions with group mean values.

7. Consistent measurements converted to a common denominator in terms of the body radius were compiled for both a Reference Man and a Reference Woman.

8. Complementary relationships were revealed for upper and lower trunk, and upper and lower extremity measurements of men and women.

9. With refinements and standardization of anthropometric and roentgenogram techniques, the estimate of LBW from the size of the "skeleton" apppears to be a reliable reference standard both in health and disease.

ACKNOWLEDGMENT

I am indebted to Dr. William Siri of the Donner Laboratory of Medical Physics, University of California, for the body density and total body water determinations on the 31 subjects. I am most grateful also to Dr. Otto Guttentag and Dr. Carroll Brodsky for the anthropometric measurements.

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AMERICAN NEGRO-WHITE DIFFERENCES IN THE THERMAL INSULATIVE ASPECTS OF BODY FAT

BY PAUL T. BAKER *

Anthropology Branch EPRD Quartermaster Research and Engineering Center, Natick, Massachusetts

STUDIES on American White men have indicated that subcutaneous body fat acts as an insulation when the total body is exposed to moderate cold stress (Baker and Daniels, 1956; LeBlanc, 1954). For subcutaneous fat to act as insulation for the body, the blood flow to the surface must be scant, otherwise, the deep body heat produced by metabolic action would be transported to the surface and lost through the skin to the cool environment. Given the phenomena of substantial sub-adiposal vaso-constriction, the total body will be insulated according to the thickness and distribution of the subcutaneous fat. Insofar as the two characteristics may vary from one race to another, it does not seem safe to assume *a priori* that the insulative characteristics of body fat found for one racial group necessarily hold for others. It is hard to imagine racial groups which are totally lacking in a vaso-constrictive response to cold stress, but it is quite possible that there exist many shadings in degree. It is also reasonable to assume that since there are such exotic fat distributions as those shown by Bushman female, there may be substantial racial difference in subcutaneous fat distribution as well as fat quantity. This assumption is in part supported by the skin fold thickness distributions shown by Newman (1956) for American Negroes and Whites.

As part of a large study on American Negro and White reactions to cold stress, an effort was made to determine whether comparable measurements of subcutaneous fat produced comparable effective insulation for these racial groups.

To rule out group differences in physiological responses due to known morphological factors, 18 Negroes and 18 Whites were matched for body weight, stature and body fat. Selection on this basis provided a non-representative population sample as it has been shown by Newman (1956)

* Present Address: Department of Sociology and Anthropology, The Pennsylvania State University, University Park, Pennsylvania.

that American Negro soldiers have less fat on the average than White soldiers of the same age. The final group reported on in this paper contains only 17 Negroes because of the inability of one subject to complete the experiment.

METHODS

Using the Harpenden caliper (Tanner and Whitehouse 1955), skin-folds in the present series were measured on the right side at:

Arm—posterior aspect midway between acromion and the olecranon process.

Chest[1]—juxta nipple—with caliper in line with the anterior of the axilla.

Chest[2]—on the mid-axillary line at the level of the xiphoid process.

From these skin-fold measurements, body fat was estimated using the regression equation described by Pascale *et al.* (1956). The Whites had a mean body fat of 9.8% with a 1.5 standard deviation. The Negroes averaged 9.2% with a 1.5 standard deviation. Body weight was matched within one kilogram, stature within a centimeter.

The group, dressed only in shorts, was equilibrated in a neutral temperature room for one hour before being exposed to the cold. They were then wheeled into a cold room in canvas chairs where they sat for two hours. At the end of the cold exposure they were wheeled back into the neutral temperature room where they were studied for a 30 minute follow-up period. The cold room was maintained at a dry bulb temperature of 50°F (10°C), relative humidity 50%, wind 5 mph. The neutral room was 80°F (26.7°C), relative humidity 50%. All individuals were exposed to the experimental conditions twice.

Body temperatures in this study were measured by means of thermocouples. Skin temperature was measured at 11 different points and integrated into a mean weighted skin temperature. (Baker and Daniels 1956). These skin temperatures were recorded continuously during the equilibrating pre-cold period (at 26.7°C), during the cold exposure and during the post-cold rewarming period. Rectal temperatures were measured with a thermocouple mounted in a flexible catheter (Davidzick *et al.* 1953). Readings were made from a potentiometer every 15 minutes during the test periods described above.

TABLE 1

Mean weighted skin and rectal temperatures for selected time intervals

	Skin Temperature							
	Whites				Negroes			
	Mean		SD		Mean		SD	
End of Equilibration Period	90.8°F	32.7°C	.9°F	.58°C	90.5°F	32.5°C	.8°F	.44°C
Time in Cold — 15 min.	78.8	26.0	1.5	.83	77.7	25.4	1.3	.72
Time in Cold — 60 min.	75.9	24.4	1.8*	1.00	74.5	23.6	1.0*	.55
Time in Cold — 105 min.	74.6	23.7	1.8*	1.00	72.8	22.7	1.0*	.55
After 15 min. rewarming	84.5	29.2	.8	.44	83.4	28.6	.9	.50

	Rectal Temperature							
	Whites				Negroes			
	Mean		SD		Mean		SD	
End of Equilibration Period	98.3°F	36.83°C	.35°F	.19°C	98.3°F	36.83°C	.31°F	.17°C
Time in Cold — 15 min.	98.3	36.83	.43*	.24	98.3	36.83	.26*	.14
Time in Cold — 60 min.	98.5	36.94	.55*	.31	98.4	36.89	.31*	.17
Time in Cold — 105 min.	98.2	36.77	.70	.39	97.8	36.55	.50	.28
After 15 min. rewarming	97.4	36.33	.96*	.53	96.8	36.00	.58*	.32

* Racial Difference, significant at the .05 level or better.

RESULTS

For the present analysis not all readings were investigated. Instead, selected readings, when skin and rectal temperatures were recorded simultaneously, have been used. The means and standard deviations shown in table 1 are the averages of the results obtained from the two cold exposures.[1]

The mean values show some mean differences which are discussed by Iampietro *et al.* in a different article on this study (in press). However,

TABLE 2

The correlation of per cent body fat to selected rectal and mean weighted skin temperature readings

	MEAN WEIGHTED SKIN TEMPERATURE		RECTAL TEMPERATURE	
	Whites (N-18)	Negroes (N-17)	Whites (N-18)	Negroes (N-17)
	r	*r*	*r*	*r*
End of Equilibration Period	—.50*	—.42	.16	—.08
Time in Cold — 15 min.	—.56*	—.54*	.55*	.27
Time in Cold — 60 min.	—.57*	—.36	.52*	.28
Time in Cold — 105 min.	—.67*	—.57*	.49*	.36
After 15 min. rewarming	—.40	—.35	.47*	.60*

* *r* significant at the .05 level or better.

the standard deviations also show considerable differences between the two groups. With a few exceptions, there is a significant racial difference in the variance. Because the groups were matched for the factors known to affect body temperatures the variances were compared using an F ratio technique. The fact that the means are in some places significantly different from each other makes a statistical comparison of the variances not completely accurate. However, the error involved is small and the statements concerning the significance of the differences should be approximately correct.

[1] In another analysis of this material presented by Iampietro *et al.* only the data obtained in the second run is presented. Since no statistically significant difference between the results of the two exposures was found, data from both exposures were used for this article.

The difference in standard deviation suggested that there might also be Negro-White differences in the effect of subcutaneous fat on body temperatures during cold exposure. Table 2 shows the correlations of body fat to those temperature measurements.

The correlation coefficients of body fat to skin and rectal temperatures found in Whites are the same direction and of similar magnitude to those reported by Baker and Daniels (1956) when a different group of White men was exposed to 60°F for two hours. However the r values for the Negroes are lower and often not significant. This would appear to be partially a consequence of the lower variability in Negro temperature responses. However, the consistency of the correlation coefficients for the Negroes in relation to the comparable figures for Whites indicate that body fat also has a biologically significant relationship to Negro body temperatures in the cold.

To demonstrate the racial differences in the role of fat in temperature regulation, regression equations were derived for all the periods, with the exception of pre-cold rectal temperature and post-cold mean weighted skin temperatures (where no significant correlation was found for either group). From these regression equations, predictions at each time interval were made for 7, 9, 11 and 13% of body fat. These values were plotted to characterize the cooling curves for individuals with these differing degrees of adiposity. The results are shown in figures 1 and 2. Although only four points were evaluated for each cooling curve, these points were connected with a curve because of the known characteristics of body temperature cooling curves (Baker and Daniels 1956).

An inspection of these figures indicates that at all time intervals, variation in fat for the Whites produces greater variations in body temperatures than comparable fat variation among the Negroes. This racial difference seems to increase with length of time in the cold so that at the end of the cold exposure period there is the greatest difference in skin temperatures, and during the rewarming period there is the greatest difference in rectal temperatures. At the last reading made in the cold, a Negro with 7% body fat had a predicted skin temperature 3 degrees Fahrenheit lower than a comparable White; while a Negro with 13% fat had only a 0.8 degree F lower skin temperature. After 15 minutes of rewarming, the Negro with 7% body fat was predicted to have a rectal temperature 0.2 degree F lower than the White with comparable adiposity. However, the Negro with 13% body fat had a rectal temperature some 0.8 degree F lower.

DISCUSSION

The present study supports the conclusion that subcutaneous fat acts as insulation during cold exposure but it also indicates that comparable amounts of adiposity on Negroes do not appear to act as comparable barriers to heat loss. This might be no more than a product of only three direct measurements of skinfolds. The formula for predicting fat was derived from results obtained on Whites only, and a markedly dif-

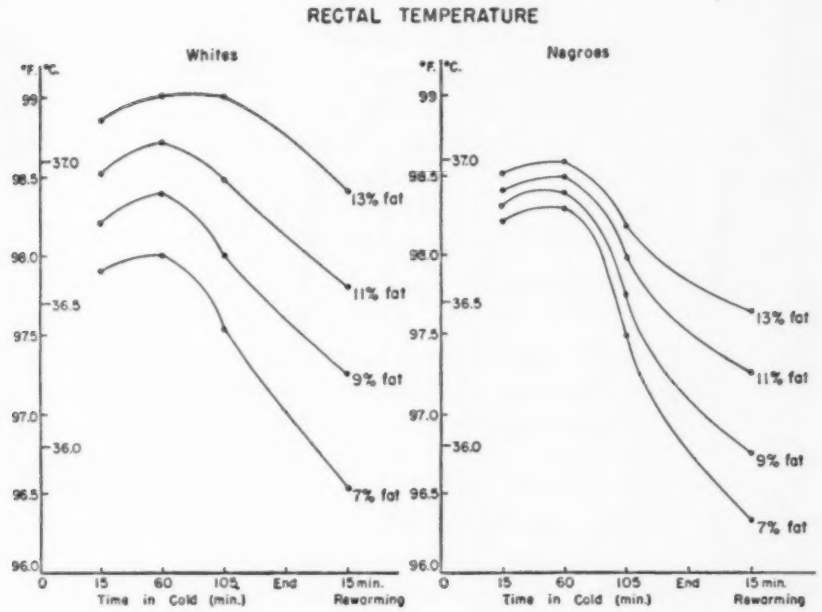

FIG. 1. RECTAL TEMPERATURE COOLING CURVES FOR AMERICAN NEGROES AND WHITES. POINTS ON THE GRAPHS ARE DERIVED FROM THE PREDICTION REGRESSION OF TEMPERATURE ON BODY FAT. AMBIENT TEMPERATURE 50°F.

ferent patterning of fat might exist for the Negro. The high intercorrelation between subcutaneous fat measurements demonstrated by Garn (1954), does not seem to support the idea of major error in this area. However, after investigating the interrelations of skinfolds for both Whites and Negroes, Newman (1956) concluded that there were patterning differences between young men of the two races, indicating that a formula calculated for Whites might not hold for Negroes. Even though the formula might not be completely valid as applied to American Negroes it is difficult to see how the errors involved could have led to

the selection of a Negro group with a much more limited range in body fat than Whites. Since, in many cases the standard deviation for Negroes in body temperature was only a little over half the value for Whites, we would have to assume an error of this magnitude before the racial differences in temperature response to cold could be explained on the basis of poor subcutaneous fat estimates.

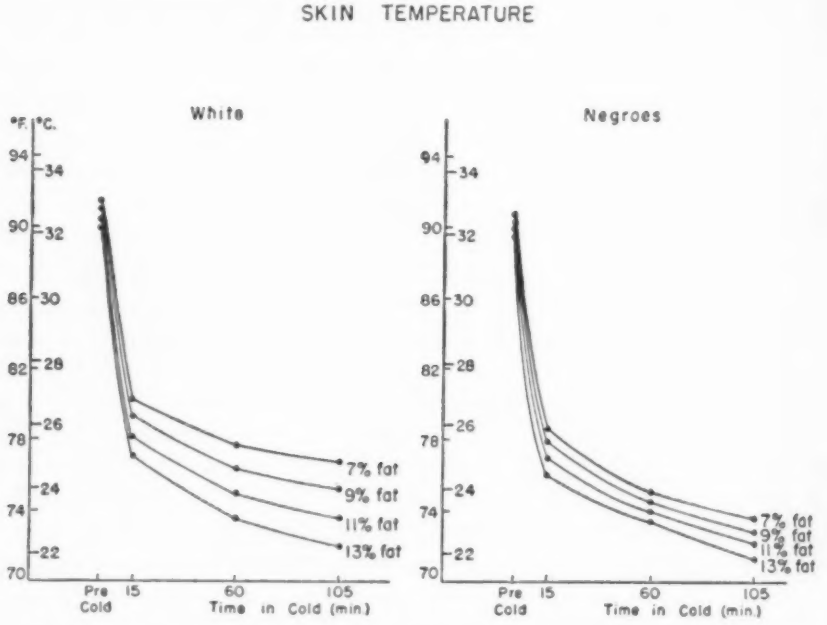

FIG. 2. MEAN WEIGHTED SKIN TEMPERATURE (11 POINT MEASUREMENT) COOLING CURVES FOR AMERICAN NEGROES AND WHITES. POINTS ON THE GRAPHS ARE DERIVED FROM THE PREDICTION REGRESSION OF TEMPERATURE ON BODY FAT. AMBIENT TEMPERATURE 50°F.

Another possible explanation is based on the fact that internal to external heat exchange in the cold is affected only by the immediate fat between the muscle and skin surfaces and is probably not affected by internal deposits of fat. Hooton (1946) and Schultz (1925) demonstrated that the American Negro has relatively longer forearms, hands, legs and feet than American Whites of the same stature. This suggests that, although the present samples of races were very closely matched for height and weight, the Negroes may have had greater surface areas, and this surface area may not have been distributed in the same propor-

tions. If, as seems probable, the Negro has a greater percentage of his surface area in the extremities, then the findings of this study could be explained by the fact that subcutaneous fat is concentrated centrally and greater quantities of fat would do very little to reduce heat loss in the forearm, leg, hand and foot. This would also explain the lower correlation coefficients for Negroes between body fat and body temperatures since, again, variations in fat would have scant effects on far extremity heat losses.

There remains also a possible racial difference in the degree of subadiposal vaso-constriction. If such a difference existed, it would also produce the racial differences in body temperature variation noted in this study. A study in which the subjects were carefully matched for local distribution as well as total body fat should help in choosing between the proposed alternative explanations.

CONCLUSIONS

Irrespective of the merit of the above speculations, three conclusions may be derived from the data.

First: Body temperatures of the American Negroes in this study showed significantly less variation than the American Whites, even though the groups were matched for the known body morphology factors which affect these temperatures.

Second: Significant correlation between adiposity and body temperatures were found for both Negroes and Whites. Since the American Negro soldier has substantially less subcutaneous fat than the American White soldier, representative samples would have shown the Negro-White rectal temperature difference greater than reported in this study when both were placed in these experimental cold conditions.

Third: Although significant correlation was found, the majority of body temperature variation was not accounted for by subcutaneous fat; nor can it be explained by metabolic variations since the means and standard deviations for oxygen consumption on the same subjects were found by Iampietro (in press) not to be significantly different.

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SECULAR CHANGE IN THE INTELLIGENCE OF 11-YEAR-OLD ABERDEEN SCHOOLCHILDREN

BY

A. W. BOYNE

Rowett Research Institute, Bucksburn, Aberdeen, Scotland

AND

J. R. CLARK

Education Department, City of Aberdeen, Scotland

IN the course of their review of secular change in height and weight of British children, Boyne, Aitken and Leitch (1957) found evidence from data obtained between 1914 and 1953 that girls were overtaking boys in weight at an earlier age in the latter half of this period than in the first part. From the data for 14-year-old children for the years 1948 to 1953, they detected a highly significant trend in both height and weight in that the boys were taller than the girls by a progressively increasing amount [$P < 0.001$], and the weight advantage which girls held over boys became progressively less, between these years [$P < 0.02$]. Since Bayley (1956) and other writers have pointed out that the adolescent spurt in girls occurs two years earlier than in boys, these results suggested that the physical growth spurt associated with puberty was starting earlier year by year.

Although British records do not go far enough back, Tanner (1958) has quoted Norwegian statistics to show that the average age of a girl's first menstruation has fallen from 17 years in 1850 to 13¾ years today. Presumably there has been a corresponding shift in the age at which puberty occurs in boys. Cuthbertson (1958) in his review on the adolescent quotes several workers who have demonstrated that maximal height is becoming greater and is being reached progressively earlier.

In this paper the authors examine the results of intelligence tests carried out in Aberdeen on 11-year-old children, to see whether these suggest any secular change in intelligence corresponding to the physical changes outlined above.

OTHER INVESTIGATIONS

The two principal investigations into changes in intelligence in Great Britain have been those of Emmett (1950) and the Scottish Council for Research in Education (1949). Emmett in 1950 reported the results of his investigations into the trend of intelligence in certain parts of England. He included only those districts where the children examined before and after the war were considered to be comparable. In 1947 in each educational authority district the children were submitted to a Moray House Intelligence Test[1] for 11-year-olds which had been carried out, on average, some 9½ years earlier in that area. Wherever possible, the results for boys and girls were examined separately when appropriate adjustments had been made for differences in the age at which the early and late groups of children had been tested. The results were interpreted on the basis of the actual scores made in the tests and on the derived intelligence quotients (I. Q.). The author's main conclusion was that a highly significant fall in the I. Q. of boys and an equal rise in the I. Q. of girls had taken place over the period.

Commenting on this result, Emmett stated that on the whole the conditions under which the two tests were made and the composition of the two groups were as nearly comparable as it was possible to make them. It was his opinion that changes in schooling probably caused the scores in the second test to be depressed, although it was impossible to determine the extent of this effect.

In the Scottish study no sex difference in I. Q. was found in the pre-war group of children, but in the post-war group there was a significant difference in favor of the girls.

Whatever interpretation be placed upon changes in absolute values over the war years, there is little doubt that at the time of the 11+ examination the intelligence of girls, as measured by the test, had improved relative to that of boys over this period.

In three of the districts in which girls in 1947 had a higher I. Q. than boys at 11+ years, Emmett later carried out a test when the children were 13+ years old. He found that the superiority of girls over boys fell significantly between these two ages and concluded that the general post-war superiority of girls at 11+ was transitory, attributing the sex

[1] The Moray House intelligence tests are verbal, objective, timed, group tests of intelligence which are prepared every year by the Education Department of the University of Edinburgh and are published by the University of London Press for restricted sale to Education Authorities throughout Great Britain.

difference to some change in environment since the pre-war years which had a different effect on each sex.

Secular change in mental age among certain Canadian schoolchildren was examined by Binning (1958). He compared the I. Q.'s of Saskatoon schoolchildren in 1946-7 and 1955-6, and found that an increase had taken place over this period. The change in mental age was accompanied by faster growth in height and weight, by an earlier loss of visual acuity, and probably also by an earlier onset of puberty. Binning, however, did not make a sex comparison, nor did he specify the age of the children, but from the context this appears to have been about 12-13 years.

In these three investigations quoted, an attempt was made to assess changes in intelligence by comparing the test-passing ability of children on two occasions separated by a number of years. The two British investigations suffer the handicap that the later groups of children were schooled during the war years with all their associated disruptive effects. Emmett was aware of this, and considered that this depressed the absolute scores obtained on the second occasion. But Tanner (1958), in an address to the Oxford Institute of Education, considered that it was impossible to tell whether there had been advances in mental age over the years, since the advance of maturation meant that comparing the test-passing ability of a ten-year-old now and that of one 30 years ago would not be comparing like with like. To this we would add that over such an extended period there must also have occurred a great change in the way of life, another relevant factor.

THE PRESENT INVESTIGATION

In view of the difficulties of interpreting changes in I. Q. mentioned above, it was decided not to attempt this, but to pursue further the sex differences encountered by Emmett and the Scottish Council.

Compared with many other parts of the country, Aberdeen possesses a stable population, in that the community is very self-contained, and there is little population movement between it and other regions. Complete records have been kept by the Department of Education for the City of the results of 11+ examinations from 1946 to the present date, and an examination was made of the data pertaining to 1947 and 1957. 1946 was not selected, lest there might have been some abnormality in the results of the tests during this first post-war year which was also the first year in which a test had been carried out since before the war. The year 1957 was the latest available at the time of the enquiry.

In each year two Moray House Intelligence Tests were applied to the children by their teachers. The results of the first of these were analysed, after they had been adjusted for each child to an age of 11 years. Each year approximately 3000 children were tested. The results in table 1 show that the I. Q. of the girls relative to that of the boys had

TABLE 1

Mean I. Q. of boys and girls separately in 1947 and 1957

	BOYS	GIRLS	DIFFERENCE (B-G)
1947	102.1	101.3	0.8
1957	104.6	105.5	—0.9

Improvement of girls relative to boys between 1947 and 1957 = 1.7 ± 0.79.

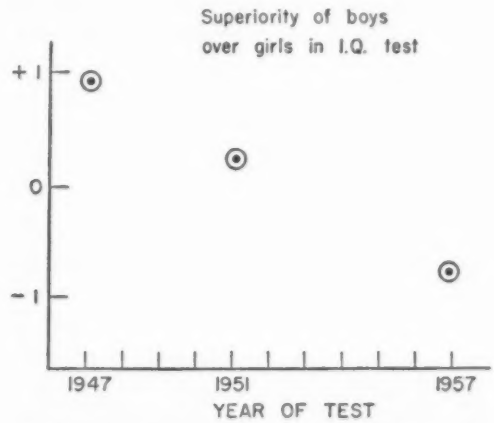

FIG. 1. SECULAR CHANGE IN RELATIVE INTELLIGENCE OF BOYS AND GIRLS AS MEASURED BY MEAN DIFFERENCE IN SCORE (ADJUSTED FOR AGE) IN 11+ MORAY HOUSE INTELLIGENCE TEST.

risen between 1947 and 1957 by 1.7 points [$P < 0.02$]. As there might, by chance, have been a change in the test so that the later one favored girls more than the first had done, the results from an intermediate group were examined. For reasons unrelated to this enquiry it was most convenient to use the data from 1951. When the average superiority of boys over girls is plotted against year of examination, as in figure 1, the three points lie very nearly on a straight line. The change, whatever its cause, seems to be gradual, and has been taking place since pre-war years.

These Aberdeen data were examined further. Table 2 shows the age distribution of the children tested on each occasion. It is similar for boys and girls, but the age distribution in 1947 is very different from those in 1951 and 1957. Such differences as exist between the age distributions in 1951 and 1957 are probably due to the effects on birth rate of the onset and ending of the war. There is a greater proportion of older children in 1947, probably a carry-over from war-time conditions in schools. The average age at test is 11 years 10 months in 1947, 11 years 7 months in 1951 and 11 years 6 months in 1957.

TABLE 2

Age distributions by sex of children tested in 1947, 1948, 1951 and 1957

	1947		1948		1951		1957	
AGE IN MONTHS	B	G	B	G	B	G	B	G
–126	3	2	1	0	1	0	0	0
126–129	7	3	7	3	3	0	2	1
129–132	22	22	24	34	36	27	19	20
132–135	117	111	131	110	139	134	215	207
135–138	201	224	305	282	274	262	381	357
138–141	219	285	313	327	313	279	344	304
141–144	288	278	318	312	290	280	272	232
144–147	216	224	215	185	158	164	142	141
147–150	136	118	113	112	46	33	18	21
150–153	107	82	93	69	1	9	0	1
153–156	26	23	25	19	5	5	0	1
156–159	37	36	28	18	4	3	0	0

Most children tested were between 11 years and 12 years 3 months old at the time of the test in 1951 and 1957. The children outside this age range had been promoted or retarded from the classes tested in the subsequent or previous years respectively, and by analogy few children outside this age range had been promoted or retarded to the classes tested in 1950, 1952, 1956 or 1958. The intelligence quotients and sex differences are given in table 3 for this control block of children at three-monthly intervals, and also for the corresponding groups of children in 1947, although the 1947 children may not be strictly comparable with the other groups, as a result of the greater numbers who had been retarded into the 1948 group. This is shown in table 2 where the age distribution of children tested in 1948 is also given, and those over 12 years 3 months of age were almost all retarded from the 1947 group.

There were irregularities, as would be expected with such small numbers, but the tendency was for the shift in favor of the girls to be present at all ages. This age range, from 11 years to 12 years 3 months, has also manifested a similar shift in favor of girls with respect to physical measurements (Cuthbertson, 1958) as a result of the earlier timing of the adolescent spurt in girls. The effect of the earlier spurt in boys, as manifested by the change in age at which boys overtake girls physically, does not show itself until about 14 years of age (Boyne *et al.*, 1957). Analogous to this there were the results of Emmett's examination of the intelligence in 1949 of 13-year-old children who had been examined at 11+ years in 1947. These showed that the superiority which the girls had achieved at 11+ years was transitory and the superiority of the boys was re-established by the time of the second examination. Emmett regarded the superiority of the 11+ girls in 1947 as a result of environmental change and he suggested that the effect of the war years was more detrimental to the boys than the girls. But in the years following the war, with the re-establishment of peace-time conditions and the return of fathers to disrupted families, the same intelligence trend continued at 11 years of age.

TABLE 3

Mean I. Q. at 3-monthly intervals of central group of children tested in 1947, 1951 and 1957 [1]

AGE IN MONTHS	1947			1951			1957		
	B	G	B-G	B	G	B-G	B	G	B-G
132–135	111.3	107.6	3.7	109.9	110.0	—0.1	109.0	110.5	—1.5
135–138	108.4	107.4	1.0	104.2	104.0	0.2	104.0	105.1	—1.1
138–141	107.7	104.1	3.6	101.7	101.6	0.1	104.6	105.2	—0.6
141–144	102.7	102.8	—0.1	100.1	100.4	—0.3	104.2	103.8	0.4
144–147	99.7	98.8	0.9	98.6	98.0	0.6	99.8	103.7	—3.9

[1] It is of interest that the I. Q. of the youngest children tends to be high, that of the oldest children low. This does not reflect unfavorably on the age correction, but arises because the first group contains a leavening of children promoted from the following class at some stage in their school career, and the last group contains a number of children retarded from the previous class.

DISCUSSION

If, as reported by Emmett, the fall in intelligence of the boys over the war years was real, then the situation is complicated and difficult to explain, but Emmett himself, as reported above, and Tanner (1958), have commented on the difficulties of comparing absolute values of intelligence in different years. Otherwise, these results here reported are entirely analogous to the accepted position in physical growth, where the female adolescent spurt precedes that of the males by about two years and both are occurring earlier year by year.

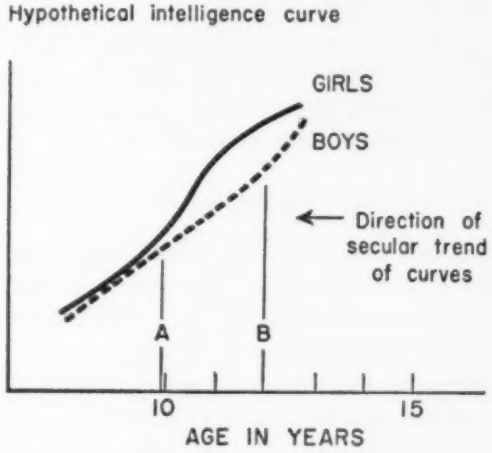

FIG. 2. HYPOTHETICAL INTELLIGENCE-AGE CURVES TO ILLUSTRATE THE SUGGESTED EFFECT OF AN ADVANCING ADOLESCENT SPURT UPON THE RELATIVE INTELLIGENCE OF BOYS AND GIRLS.

Figure 2 suggests a reason for the change in I. Q. difference between the sexes. It shows hypothetical curves of intelligence plotted against age. These are similar in shape to weight curves and it is suggested that growth in intelligence may follow a similar pattern to weight increase, *i. e.*, in each sex there is an acceleration in growth rate associated with adolescence, and over the years this spurt has gradually occurred at an earlier age in the child. At the time to which the diagram refers the onset, A, of the girls' adolescent spurt in intelligence takes place at about ten years of age, that of the boys, B, about 12. A comparison at age 11 years would show the girls to be slightly more intelligent than the boys. Some years earlier the curves would have been displaced to the right

with respect to the age scale and a comparison at age 11 years would have shown little or no sex difference. Some years later a comparison at the same age would show a greater difference in favor of the girls as the curves would be displaced to the left relative to the age scale.

It would be dangerous to force the analogy further, and suggest that, as in physical growth, a greater intelligence is being attained with the passage of the years. Indeed, there may well be other explanations for the phenomena reported here, but the one put forward is consistent with changes which have taken place in physical growth, and it would be of great interest to know whether data from other centers confirm the trend described in this paper.

The authors wish to express their indebtedness to Dr. J. D. Nisbet, of the Education Department of the University of Aberdeen, and to Dr. D. P. Cuthbertson, Director of the Rowett Research Institute, for stimulating discussions relevant to this investigation.

SUMMARY

Work has been reported, pointing out that the adolescent physical growth spurt, which occurs about two years sooner in girls than in boys, has been occurring progressively earlier in Great Britain and elsewhere. The maximal height attained has also become greater over the years.

This investigation provides data relevant to secular change in intelligence with particular reference to the difference between the sexes. It is concluded, after reference to earlier work and an examination of fresh data obtained from the City of Aberdeen Education Department, that the intelligence of girls at 11+ years of age, as measured by the Moray House Intelligence Test, has been improving relative to that of boys from before 1939 until the present day.

From the Aberdeen data examined in 1947, 1951 and 1957, it appears that the change in relative intelligence occurs in all the children between 11 years and 12 years 3 months of age. One worker showed that the superiority of girls at 11 years in 1947 was significantly reduced at 13 years of age in 1949. It is suggested that a secular advance of the adolescent spurt in mental growth, parallelling the advance in the physical growth spurt, offers a satisfactory explanation of the results reported in this paper.

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ARM STRENGTH AND BODY DIMENSIONS

BY D. F. ROBERTS, K. A. PROVINS[1] AND R. J. MORTON[1]

Department of Human Anatomy, Oxford

THERE has been a number of investigations (reviewed in Cureton, 1947; Hunsicker and Greey, 1957) of the relationship between strength and physique. Claims for their positive association in adults have been based primarily on studies in which strength has been assessed by some composite index, derived from a battery of dynamometer and performance tests, and physique has been rated in terms of endomorphy, mesomorphy and ectomorphy, though actual values of the correlation coefficients have not been high. Morphology assessed metrically, however, for example by the aid of limb girths or volume, has shown both in men and women such low correlations with strength indices that Cureton was led to report (*op. cit.*, p. 362) that the size of arms and legs fails to indicate their strength, while overall measures of body size, height and weight singly and together, also have given low correlations with strength indices. On the other hand when the strengths of specific muscular actions are considered, particular anthropometric measurements are seen to assume some importance. For example, forearm girth corrected for fat was shown by Carpenter (1938) to be significantly correlated with grip; Clarke (1954) demonstrated the importance of upper arm girth (flexed-tensed) in the strength of shoulder movements and of elbow flexion, a lesser effect of upper arm length, and some effect of stature; Elbel (1949) showed a high correlation of leg strength with body weight. In children, the association of body size and grip strength has long been known (Metheny, 1941). In an endeavour to clarify this somewhat unsatisfactory situation it was thought worthwhile to examine the degree of association between arm strength, arm morphology in terms of length and girth measurements, and body size. Moreover the problem is of theoretical interest in view of the attention recently given (Coon, Garn and Birdsell, 1950; Roberts, 1953a, b) to the adaptive significance of limb morphology, for strength must have some selective role. The results may also be of practical assistance in questions of personnel

[1] Medical Research Council Unit for Research on Climate and Working Efficiency.

selection and human engineering, where it may be necessary to consider the actual forces that operators of a particular range of body sizes are able to exert. The work is thus a development from a series of previous investigations (Provins, 1955a, b; Provins and Salter, 1955) of the effect of limb position and other variables on arm strength, in which relative values were established for the various conditions tested.

MATERIAL AND METHODS

The subjects were young adult male Royal Naval personnel. The following seven anthropometric measurements were taken by a single observer on the nude subject:

Stature—Height to vertex, with subject standing comfortably erect, but not in the forced attitude of attention, looking horizontally before him.

Weight—Subject standing on a platform spring balance.

Upper arm length—From acromion to upper margin of head of radius, the arm hanging straight with muscles relaxed. (Right arm).

Forearm length—From upper margin of head of radius to tip of styloid process of radius. (Right arm).

Hand length—From tip of styloid process of radius to tip of middle finger, the hand being placed flat on a bench. (Right hand).

Upper arm girth—At a point midway between acromion and point of elbow, the arm hanging loosely with muscles relaxed. (Right arm).

Forearm girth—Maximum girth, the arm hanging loosely with muscles relaxed. (Right arm).

Three tests of muscle strength were administered:

Hand grip strength—Using a Salter's improved hand grip dynamometer, the subject was encouraged to exert his maximum effort; the better of two trials was recorded.

Elbow flexion strength and *elbow extension strength*—Using a strain-gauge dynamometer as described by Provins and Salter (1955), the subject was instructed to apply a steadily increasing force to the handle, attaining a maximum after about five seconds; the peak galvanometer reading was recorded. The elbow was flexed to a

right angle, and the dynamometer handle was vertical so that the subject's hand was approximately midway between pronation and supination.

The strength of grip was measured on both the right and left sides; as there was no significant difference between the means ($t = 1.507$), the value for the right hand only has been used in the present analysis. The tests of strength of elbow flexion and extension were carried out on the right side in 60 of the 75 subjects examined and on the left in the remaining 15; choice of side was determined by convenience of setting up the apparatus. In view of the relatively slight differences in performance between the two sides previously noted in this task (Provins, 1955a), the inconsistency in side used was disregarded in the present study.

TABLE 1

Means and standard deviations of measurements in the whole sample

MEASUREMENT	MEAN	S. D.	NO. IN SAMPLE
Stature	173.2 cm	6.47 cm	63
Weight	66.6 kg	6.41 kg	63
Upper arm length	32.9 cm	2.21 cm	60
Forearm length	25.7 cm	1.32 cm	60
Hand length	19.6 cm	0.83 cm	59
Upper arm girth	27.8 cm	2.04 cm	62
Forearm girth	26.7 cm	1.30 cm	62
Hand grip strength	41.6 kg	5.89 kg	72
Elbow flexion strength	5.90 kg/m	0.85 kg/m	75
Elbow extension strength	5.03 kg/m	0.89 kg/m	75

RESULTS

The mean, standard deviation, and number of subjects measured, for each of the anthropometric measurements and tests of strength employed is given in table 1. It was unfortunately not possible to record all the measurements on every subject, so that the number in the sample for each item varies somewhat. However, all the measurements listed were recorded for 41 men and in consequence the following analysis has been carried out on the data from this smaller series.

The simple correlation coefficients between the various measures of strength and anthropometry are set out in table 2. It will be seen that all the values for r are positive except those between upper arm girth and

the four longitudinal measurements taken (viz. stature, upper arm length, forearm length and hand length); none of these four however is statistically significant. Forearm girth shows low positive correlations with the four longitudinal dimensions although the value for r is significant only in the case of hand length. As expected, the measures of girth are quite highly correlated with one another and with body weight, while there is a similar good correlation between the various measures of length.

TABLE 2

Correlation Coefficients

MEASUREMENTS	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
(a) Stature	—								
(b) Weight	0.48	—							
(c) Upper arm length	0.75	0.49	—						
(d) Forearm length	0.68	0.25	0.35	—					
(e) Hand length	0.73	0.46	0.51	0.77	—				
(f) Upper arm girth	—0.19	0.56	—0.10	—0.06	—0.02	—			
(g) Forearm girth	0.26	0.74	0.16	0.22	0.39	0.70	—		
(h) Hand grip strength	0.48	0.42	0.41	0.41	0.47	0.19	0.38	—	
(i) Elbow flexion strength	0.45	0.47	0.34	0.47	0.59	0.40	0.64	0.56	—
(j) Elbow extension strength	0.44	0.68	0.41	0.21	0.42	0.44	0.70	0.31	0.63

Significance levels: 5%, $r = .30$
1%, $r = .39$
0.1%, $r = .49$

The measures of elbow flexion and extension strength are quite highly correlated with one another; they are significantly correlated with grip strength and with the various anthropometric measurements except in the case of elbow extension strength and forearm length. Hand grip strength however tends to be less closely correlated with the girths and weight than are the other measurements of strength.

Table 3 shows the multiple correlation coefficients of the strength measurements with each of the other dimensions when stature and weight are included. The values for R are slightly but consistently lower for flexion than for extension, and for grip than for the elbow strengths. By comparison with the first order correlation coefficients, when body size is included there is an appreciable increase in the fraction of the total variance—(a) of flexion accounted for by each of the other measure-

ments except extension and hand length, (b) of extension accounted for by each except forearm girth, (c) of grip strength accounted for by each except flexion and hand length.

That the dependence of strength on the limb measurements is not due entirely to their mutual association with body size is confirmed by the

TABLE 3

Multiple correlation coefficients

	GRIP STRENGTH	ELBOW FLEXION STRENGTH	ELBOW EXTENSION STRENGTH
Upper arm length, stature and weight	0.52	0.54	0.69
Forearm length, " " "	0.54	0.59	0.70
Hand length, " " "	0.55	0.63	0.70
Upper arm girth, " " "	0.56	0.69	0.72
Forearm girth, " " "	0.55	0.73	0.76
Hand grip strength, " " "	—	0.63	0.69
Elbow flexion strength, stature and weight	0.62	—	0.77
Elbow extension strength, " " "	0.52	0.66	—

TABLE 4

Standard partial regression coefficients

	GRIP STRENGTH	ELBOW FLEXION STRENGTH	ELBOW EXTENSION STRENGTH
Upper arm length excluding stature and weight	+0.05	—0.12	0.00
Forearm length " " " "	+0.19	+0.35	—0.09
Hand length " " " "	+0.25	+0.50	+0.08
Upper arm girth " " " "	+0.29	+0.66	+0.30
Forearm girth " " " "	+0.24	+0.74	+0.48
Hand grip strength " " " "	—	+0.38	—0.02
Elbow flexion strength " " " "	+0.39	—	+0.39
Elbow extension strength " " " "	—0.03	+0.53	—

standard partial regression coefficients (table 4). When the effects of stature and weight are excluded, prediction of flexion strength appears to depend especially on the girths of the lower and upper arm, less markedly on the lengths of hand and forearm and not at all on upper arm length, while the other measures of strength are also important.

To a much lesser extent, prediction of extension strength also appears to depend primarily on forearm and upper arm girths but is entirely independent of the longitudinal measurements of the arm. Estimation of grip strength appears to depend on arm girths and hand length to some extent but the regression coefficients are quite low in each instance. Flexion strength appears to be very important in predicting both strength of grip and strength of elbow extension.

To examine the pattern of association further, the method of factor analysis described by Burt (1940, 1944, 1947) was employed. The saturation values for each factor derived by Hotelling's method of principal components are set out in table 5. It will be seen that all the variables

TABLE 5

Factor saturations

	FACTOR I	FACTOR II	FACTOR III
(a) Stature	.757	—.545	—.179
(b) Weight	.790	.329	—.316
(c) Upper arm length	.635	—.413	—.550
(d) Forearm length	.628	—.495	.444
(e) Hand length	.786	—.395	.216
(f) Upper arm girth	.376	.836	.117
(g) Forearm girth	.730	.574	.076
(h) Hand grip strength	.661	—.099	.205
(i) Elbow flexion strength	.801	.146	.307
(j) Elbow extension strength	.758	.329	—.256

show a high factor saturation for the first factor (except perhaps upper arm girth). The second, bipolar factor shows positive saturation values for the circumferential, weight, and strength measures (except grip) but negative saturations for all four measurements of length. The third factor appears to be positively associated with strength of elbow flexion and grip, the arm girth measurements and forearm and hand length, but negatively associated with height, weight, strength of elbow extension and upper arm length. The first factor accounts for 52.9% of the total variance and the second and third factors for 21.5% and 9.3% respectively. The interpretation of these results will be considered in relation to other methods of analysis in the discussion.

DISCUSSION

(i) *The sample.* The heights and weights of the 63 men shown in table 1 are somewhat above the average reported by Martin for the general population of men in Britain aged 20–21 years (mean stature 171.45 cm, S. D. 6.65 cm and mean weight 61.55 kg, S. D. 7.50 kg). Part of this difference is probably due to sampling error, as larger samples of the height of Royal Naval personnel (Geoghegan, 1953; Geoghegan, Roberts and Willson, 1957) give values slightly lower than that shown here, but weight somewhat higher. It may be partly due to a slight age effect, since the average age of the present sample was 21.9, or to the observed secular trends, since Martin's figures were obtained in 1939, while the present work was undertaken in 1953. Other contributory explanations may lie in the medical selection of enlisted personnel since Martin's data include those rejected for service, or the regional basis of naval recruiting referred to by Geoghegan (1953), for in the present small sample, 40 of the 63 men examined were drawn from parts of Britain recording a higher mean value for both heights and weights than the national average (Martin, 1949).

The results suggest that motivation was good. The values for grip strength recorded in the present survey are lower than might have been expected from other investigations (Jones, 1949; Burke, Tuttle, Thompson, Janney and Weber, 1953) although the absolute values recorded are notoriously dependent on the instrument used (Metheny, 1941). However, the results of the tests of elbow flexion and extension strength are directly comparable with the values previously recorded with the same instrument in the studies by Provins (1955) and Provins and Salter (1955). These investigations included both male and female subjects, but the results for male subjects alone agree closely with the present findings for flexion and are slightly lower than the present values for extension.

(ii) *The findings.* The following interpretation of results should only be regarded as tentative, for the present work is based on a small number of subjects (41) and in factorial studies the type of result obtained is dependent not only on the form of analysis employed (Thurstone, 1946, 1947) but also on the number and range of the original measurements (Howells, 1951). In essence, however, the findings are closely in accord with those implicit in Clarke's (1957) study of the relationship between various anthropometric measures and trunk and lower limb strengths.

First, the fact that the anthropometric and strength values are in general positively correlated with one another suggests that, on the whole, the person who tends to be large in one body dimension tends to be above average in all body measurements as well as in limb strength. This suggestion is confirmed by the high first factor saturation (table 5) for all variables and not only agrees with but extends previous evidence for a common size factor (Burt 1938, 1944; Cohen 1938, 1941; Hammond 1942; Rees and Eysenck 1945; Burt and Banks 1947; Howells 1951) to include limb strength.

Secondly, the better correlation of the longitudinal measurements with one another than with the girth measurements which also correlate well with one another and with weight is suggestive of some fundamental distinction between longitudinal and circumferential aspects of body size. This is further demonstrated by factor II, in agreement with the findings from previous factorial studies, using different body dimensions. However, while the measures of strength of elbow flexion and extension are positively loaded in factor II as are the measures of girth and weight, strength of grip by its negative saturation appears to be associated more closely with the measures of length. For this the differences in technique of measurement may provide a partial explanation. The strengths of elbow flexion and extension were measured as torques about the elbow joint, so that the value recorded in each instance is the product of the force exerted by the muscle at its insertion and the distance of the insertion from the fulcrum of the joint. In other words, for flexion and extension strength, the variable of lower arm length has been eliminated *in the method of measurement*. The amount by which this variable continues to affect the results may be an indication of the association between the distance of the muscle insertions from the elbow joint and the length of the arm. By contrast, in measuring the strength of grip, the dynamometer employed was not capable of being adjusted to variations in hand size to suit each subject. It seems likely therefore that the association of grip strength with the measures of length rather than girth may be due, at least in part, to the fixed grip dimension of the dynamometer.

Nevertheless, there is evidence for an association between grip strength and arm girth although less pronounced than that for the other two measures of strength. This is seen most clearly in tables 3 and 4 where the influence of stature and weight on the association between the various anthropometric measurements and tests of strength is considered. There

is also confirmatory evidence from the positive factor saturation of the girth measurements and grip strength for the minor factor III in table 2.

The interpretation of factor III is difficult in view of the small proportion of the variance for which it accounts, the limited number of features considered, and the small sample size. However, as the measures of overall body size are grouped with upper arm length and elbow extension strength in contrast to the other measurements recorded, it is possible that factor III may indicate local variations in the effectiveness of the common size factor.

SUMMARY

The mutual associations of arm strength, arm morphology, and body size have been examined and three factors isolated to account for the greater part of the variance. A general size factor common to all the dimensions is found to extend also to the strength measurements. A second bipolar factor, in morphology contrasting length with girth, appears to distinguish elbow strengths from grip strength; it is suggested that this is to some extent attributable to differences in technique of measurement. The effect of body size and limb dimensions, especially the arm girths, on arm strength is clearly established.

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THE GENETIC EFFECTS OF REPRODUCTIVE COMPENSATION *

BY GEORGE C. WILLIAMS

Department of Natural Science
Michigan State University
East Lansing, Michigan

THE simplest model of natural selection in a mendelian population consists of a succession of discrete generations each produced by a random combination of the gametes of the preceding generation. The zygotes show a Hardy-Weinberg distribution of genotype frequencies, which are modified by selection before the next generation of gametes is produced. Natural populations are more complicated than this, and population geneticists have analysed the effects of some of the possible complications, such as overlapping generations and varying degrees of inbreeding, and have thereby evaluated the associated departures from the general model. The present paper presents an evaluation of the effect of *reproductive compensation* on the selection of deleterious recessives.

Reproductive compensation may be defined as any influence of offspring mortality on subsequent reproductive functions of the parents. Such effects are readily imagined for human populations, in which family size may be influenced by custom. Dead infants or fetuses may be replaced until a socially desirable family size is attained. If the dead offspring were lost through homozygosity for a deleterious recessive, their replacement would obviously reduce the effectiveness of selection in removing early-acting deleterious genes from a population. Compensation might also work through ways other than custom and in populations other than human. The early death of a human embryo results in the rapid return of the mother to a physiological state in which a replacement might be produced. So even without the social pressures, compensation would operate by increasing the time available for zygote

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production. This possibility was recognized by Foy, *et al.* (1954). In viviparous animals that give birth to more than one young at a time, the death of one embryo might well mean better nourishment for the others. The number of zygotes would not be affected, but compensation would operate by raising the survival prospects for the individuals not eliminated. A formally analogous situation might be recognized in seed plants. In birds, members of smaller than average clutches have higher than average survival rates (Lack, 1954). The death of one individual would presumably result in compensation through its effect on the survival of its nest mates. Compensation is most readily credited, and is probably most important in man, but as a minor statistical effect it must be of very general occurrence.

The first recognition of this factor is attributed to R. A. Fisher (Race, 1944). Its first critical assessment was Glass' (1950) analysis of its effect on selection at the *Rh* locus. Here there is a very special situation, the adverse selection of the heterozygous (positive) offspring of positive fathers and negative mothers. Glass' data showed that there is compensation, so that such marriages produce about the same average number of surviving offspring as other marriages. He reasoned, therefore, that there was no selection between progenies with respect to *Rh*. The only effective selection is within the progenies of negative mothers and heterozygous fathers. The homozygous negative children of such parents are more likely to survive than their heterozygous sibs. Glass concluded that selection and compensation are increasing the frequency of the negative allele in the population studied. This conclusion was later confirmed by Li's (1953) demonstration of low unstable equilibrium frequencies of the negative allele in such populations.

Selection at the *Rh* locus is an unusual problem, and its solution contributes little to the general understanding of compensation as a factor in the genetics of populations. Moreover, compensation has been invoked a number of times (*e.g.*, Bianco, *et al.*, 1952, Foy, *et al.*, 1954) as a possible explanation for unusually high frequencies of lethal or demonstrably deleterious genes that produce their adverse effects in homozygotes. Such genes often have detectable effects on the heterozygote, but in their effects on viability they can be considered recessives. Analysis of this generally significant problem of the interaction of compensation and selection for genes adversely selected in the homozygote alone (recessives) or in both homozygote and heterozygote equally (dominants) was provided by Lewontin (1953). He postulated a population in which there

were two types of matings, those that were genotypically capable of producing offspring with a certain hereditary disorder (*susceptible* matings) and those that were not. His analysis indicated that selection and compensation were able, with certain reasonable rates of selection and compensation, to produce stable equilibria with the deleterious gene maintained at levels greatly in excess of those attributable to mutation pressure, and in the range often attributed to balanced polymorphism.

Lewontin's conclusion, justified by mathematical deduction, is logical on an intuitive basis as well, once his premises are accepted. At low frequencies, selection of a deleterious recessive would take place only in the progenies of matings between heterozygotes. One-fourth of the individuals in such progenies would be adversely selected. Higher gene frequencies would result in progenies in which half or all of the individuals would be of the unfavored genotype. So as the frequency of such a gene increased, not only would there be increased numbers of susceptible matings, but their average susceptibility would also increase. In Lewontin's system, however, the rate of compensation is considered constant for all types of susceptible matings. With the average effect of selection in susceptible families increasing with increasing gene frequencies, while the average effect of compensation remains the same in such families, it is easy to imagine that compensation might have a greater effect at low frequencies, that selection might be more important at higher frequencies, and that a stable equilibrium could be produced at some intermediate point.

I can conceive of no justification, however, for compensation being regarded as constant and independent of mendelian ratios in susceptible matings. Compensation has always been thought to operate through the replacement of lost offspring. This interpretation implies that there should be four times the compensation effect in a cross between individuals homozygous for a deleterious recessive as in crosses between heterozygotes. In the present paper, this assumption of direct proportionality between offspring mortality and compensation will be substituted for Lewontin's assumption of the same rate of compensation for all susceptible matings.

The usual Hardy-Weinberg model of a population provides for no consideration of feed-back from offspring to parents, such as is involved in compensation. The exact analysis of this factor might follow Lewontin's method of separate consideration of selection and compensation for all possible crosses, the summation of the appropriately modified progenies,

and the dependent calculation of the combined effects of selection and compensation on the gene frequencies of the next generation. However, the assumption of compensation as a function of offspring mortality rate enormously complicates this technique. Instead I will substitute a simplified approximation that should be nearly correct for populations in which a deleterious gene (a) is present in low frequency (table 1). The simplification consists first of all of neglecting the homozygous recessives in listing the types of crosses. This procedure is justified when the recessive gene is rare because almost all of the homozygous recessives would be produced by crosses between heterozygotes (Aa). Hence, almost all of the effects of selection and compensation would take place in the progenies of heterozygote pairs. The frequency of these heterozygotes would be $2pq$ (at conception), where p is the frequency of the dominant gene, and q the frequency of the recessive. Since p is equal to $1-q$, $2pq$ would be closely approximated by $2q$, when q is very small. The frequency of AA would therefore be close to $1-2q$, and this simplification serves here as the frequency of the homozygous dominant. The greater mortality rate among the aa offspring (they have a disadvantage symbolized by s) is assumed to result in compensation to the extent c, so that the progeny of two heterozygotes is increased by the factor $1+c$.

Note that the simplifications (table 1) involve only the parental genotype frequencies. As long as there is random mating, this will have no effect on offspring genotype frequencies. The offspring will show a Hardy-Weinberg distribution and will be affected by selection in the same way regardless of the genotype frequencies of the previous generation. So no error is introduced with respect to the selection factor, $1-s$. It is only for the effect of compensation that the model is inexact and applicable only for low values of q. Also note that the model is exact even for compensation in the special case of a lethal gene. If a were lethal there would, in fact, be only two adult genotypes, and their frequencies would be exactly $2q$ and $1-2q$.

On the basis of the model the change in the frequency of a in one generation can be calculated as

$$\Delta q = q' - q = \frac{\Sigma(aa) + \frac{1}{2}\Sigma(Aa)}{\Sigma\Sigma} - q \tag{1}$$

$$= \frac{-q^2(s - 2c + sc + 4cq - sq - csq)}{1 + q^2(4c - s - cs)}.$$

This conclusion can be made meaningful by considering its application to the special cases for which it would have the most interest.

TABLE 1

Approximate model of reproduction in a population with a rare deleterious recessive subject to reproductive compensation

CROSS	FREQUENCY	OFFSPRING			
		AA	Aa	aa	Σ
$AA \times AA$	$(1-2q)^2$	$(1-2q)^2$			$(1-2q)^2$
$AA \times Aa$	$4q(1-2q)$	$2q(1-2q)$	$2q(1-2q)$		$4q(1-2q)$
$Aa \times Aa$	$4q^2$	$q^2(1+c)$	$2q^2(1+c)$	$q^2(1+c)(1-s)$	$3q^2(1+c)+q^2(1+c)(1-s)$
Σ	1	$\Sigma(AA)$	$\Sigma(Aa)$	$\Sigma(aa)$	$\Sigma\Sigma$

Case 1. *No selection* ($s = 0$) *and no compensation* ($c = 0$).

Here equation (1) gives

$$\Delta q = 0$$

the expected solution for this situation.

Case 2. *Extreme selection* ($s = 1$) *and no compensation* ($c = 0$).

Here equation (1) gives

$$\Delta q = \frac{-q^2}{1+q}$$

the expected exact solution to the problem of selection against a recessive lethal (Li, 1955:252) without compensation.

Case 3. *Extreme selection* ($s = 1$) *and complete compensation*

$$c = \frac{s}{4-s}.$$

Here equation (1) gives

$$\Delta q = -\tfrac{2}{3}q^2.$$

Complete compensation is here defined as an increase in reproductive success that exactly compensates for the loss due to $\frac{1}{4}$ of the progeny being homozygous for a. The corresponding value of c is obtained by setting the total progeny of $Aa \times Aa$ equal to its value without selection, $4q^2$, and solving for c. With complete compensation, therefore, selection is about $\frac{2}{3}$ as effective as when compensation is absent.

Case 4. *Moderate selection* ($0 < s < 1$) *and no compensation* ($c = 0$).

Here equation (1) gives

$$\Delta q = \frac{-sq^2(1-q)}{1-sq^2}$$

which is the expected solution for this situation (Li, 1955:254).

Case 5. *Moderate selection* ($0 < s < 1$) *and compensation complete*

$$c = \frac{s}{4-s}.$$

Here equation (1) gives

$$\Delta q = \frac{-\frac{1}{2}sq^2}{1-\frac{1}{4}s}$$

an approximation indicating that selection, with small values of q and s, is about half as effective with complete compensation as in its absence.

The indications are, as expected, that selection is less effective in eliminating early-acting deleterious recessives when there is reproductive compensation than when compensation is absent. It should be emphasized, however, that even with complete compensation, the changes in gene frequency still have the same sign and order of magnitude. Compensation can not actually increase the frequency of a recessive gene adversely selected in the homozygote as it can in one type of selection against the heterozygote (Glass, 1950). This is true not only for small values of c and for complete compensation ($c = \frac{s}{4 - s}$), but even for what might be termed moderate *over-compensation*, an excess of replacements over those lost. There is evidence from Glass' work and elsewhere that over-compensation actually occurs. Even with rather extreme over-compensation, ($c = \frac{1}{2}$ for a lethal), changes in gene frequencies are still negative for all meaningful values of q.

The present study, therefore, fails to confirm Lewontin's conclusion that relatively high stable equilibria can result from selection and compensation alone. The disagreement stems from differences in the use of the compensation coefficient. Lewontin assumed it to be constant for all kinds of susceptible matings, and I assumed it to be a function of the mendelian ratios expected in different kinds of susceptible matings. My analysis would indicate that compensation can accomplish no more than an elevation of the equilibrium frequency of a gene subject to adverse selection balanced by mutation pressure. Even this effect is slight, however, compared to expectations that have been expressed. Bianco, *et al.* (1952), for example, suggested compensation as a possible cause for the high incidence of Thalassemia, a fatal childhood disease attributed to a (nearly) recessive gene, in certain human populations. Calculated gene frequencies are too high to be attributed to mutation pressures, even if the mutation rate were many times greater than the highest otherwise known for man. Taking $\frac{2}{3}q^2$ and q^2 as the rates of elimination of lethal genes with and without compensation, respectively, the mutation rates necessary to stabilize a given gene frequency would likewise be in the ratio of 2 to 3. Compensation is insufficient to account for gene frequencies that could not be maintained by mutation pressure.

It seems likely that the genetic effect of reproductive compensation

might be difficult to detect, because there are so many other much more important factors operating. Inevitably, however, there must be some effect. One would expect the early developmental stages of man, and other species with highly developed parental care, to be somewhat less well purged of deleterious gene actions than comparable stages of species in which parental responsibilities end with the production of zygotes.

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ABILITY TO TASTE PHENYLTHIOCARBAMIDE AMONG ALASKAN ESKIMOS AND OTHER POPULATIONS

BY

A. C. ALLISON

National Institute for Medical Research, London, N. W. 7, England

AND

B. S. BLUMBERG

National Institutes of Arthritis and Metabolic Diseases
National Institutes of Health, Bethesda, Maryland

IN 1932, Fox observed that some people could taste crystals of phenylthiocarbamide (PTC) placed on their tongues while others could not. Family studies carried out by Snyder (1932), Lee (1934), and Blakeslee and Salmon (1935) suggested that the character was genetically controlled, non-tasters being recessive for a gene, *t*. A number of human populations were tested with crystals or papers soaked in PTC, and differences in frequency of non-tasters recorded (see Gates, 1946).

Various methods were developed for determining the taste threshold for PTC, that is, the minimum concentration that can consistently be tasted by the subject (Blakeslee and Salmon, 1935; Hartmann, 1939; Falconer, 1947; Harris and Kalmus, 1949). The most satisfactory method is the sorting test of Harris and Kalmus, which has been quite widely used in anthropological work. This paper records the results of such tests on Alaskan Eskimos and summarizes what is thought to be reliable information on the distribution of the PTC-tasting in different human populations.

SUBJECTS AND METHODS OF STUDY

The subjects were 68 Eskimos from the Northern (Inupik) language group in Alaska. The majority (55) came from the large town of Barrow at the North of Alaska, and the remainder from the village of Beaver on the Yukon River. There was a preponderance of females (41), but no sex difference was apparent in the relatively small sample tested. Subjects varied in age from 8 to 71, the majority being young

adults. Females are reported to have slightly lower PTC threshold than males, and young people a slightly lower threshold than old people (Harris and Kalmus, 1949; Barnicot, Harris and Kalmus, 1951). This difference should not materially affect the proportion of non-tasters recorded in the Eskimo population. In the test, serial dilutions of a 0.13% solution of PTC in boiled water are prepared. Harris and Kalmus originally used 13 two-fold solutions. The concentrations of PTC in the test solutions are given in table 1. Beginning with the lowest concen-

TABLE 1

No. of solution	1	2	3	4	5	6	7
PTC concentration mg./l.	1300.00	325.00	81.25	20.31	5.08	1.27	0.32

tration, the subject is asked to taste a few cc. of the solution. When a concentration is reached which the subject can taste, he is presented with 8 cups, 4 containing the PTC solution and 4 boiled tap water. If these are correctly distinguished, he is tested with more dilute solutions until his threshold is determined. If he fails to identify the 8 cups, he is given a more concentrated solution until the sorting is correct.

RESULTS

The results of the present study are recorded in figure 1. Observations on some other populations made with the same technique are presented for comparison. The PTC taste thresholds of all populations show a clear bimodal distribution, with an antimode at solution 3. This was selected as the dividing point of tasters and non-tasters.

COMMENT

The proportion of non-tasters in the Eskimo population is relatively high (26%). The only other published investigation of Eskimos seems to be that of Sewall (1939) on the Eskimos of Labrador. This was carried out with test papers, and an even higher proportion of non-tasters (41%) was recorded. What appears to be reliable information on the frequency of the PTC-tasting character in different populations is summarized in table 2 and figure 2. The overall distribution of the character is beginning to appear, although large gaps remain to be filled in. The highest reported frequency of PTC non-tasters is in India (43%) with a somewhat lower frequency (27%) in Ceylonese Tamils.

Fairly high frequencies (25 to 32%) have been found in Western Europeans, while the Welsh have a somewhat lower frequency (17%). The frequency in the Eskimos is of the same order as in Western Europeans (26%), in sharp contrast to American Indians, who have very low frequencies. Very low frequencies are also found in East and West Africans. Intermediate frequencies are found in South-East-Asians, varying from 2% in Formosa through 7% and 11% in Japanese and Chinese to 16% in Malaya.

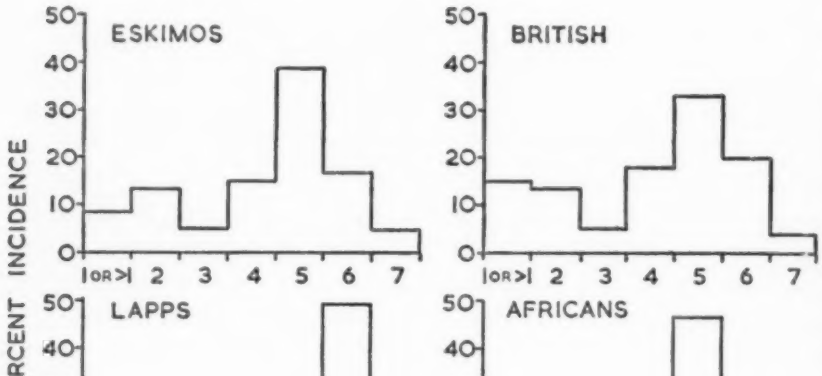

FIG. 1. DISTRIBUTIONS OF TASTE THRESHOLD FOR P. T. C. FOR ESKIMOS AND OTHER POPULATIONS.

It is worth following up clues which might lead to the discovery of selective agencies acting upon the PTC-tasting polymorphism. This is particularly true since the polymorphism appears to be a very long-standing one in evolutionary terms: Fisher, Ford and Huxley (1939) found in chimpanzees approximately the same proportion of non-tasters of PTC as is found in Western Europeans. This is not the case in some polymorphisms, such as β-amino-*iso*butyric acid excretion (Gartler, Firschein and Dobzhansky, 1956) and the serum haptoglobins (Blumberg, 1959), where all the human varieties of a trait do not appear in other primates.

TABLE 2

The incidence of non-taster of Phenylthiocarbamide and related compounds

TABLE 2

The incidence of non-taster of Phenylthiocarbamide and related compounds in different populations

POPULATION	NUMBER TESTED	PER CENT NON-TASTERS	TESTING METHOD	REFERENCE
English	440	31.5	Selection	Harris and Kalmus, 1949
U. S. White	3643	(29.8)	Crystals	Snyder, 1932
Danes	314	31.8	Selection	Mohr, 1951
Norwegians	266	30.5	"	Merton, 1958
Finns	202	29.2	"	Allison and Nevanlinna, 1952
Spaniards, Northeastern	306	24.8	"	Pons, 1955
Basques, Spain	98	(25.0)	Paper	Boyd and Boyd, 1937
Lapps, Norwegian and Swedish	140	6.9	Selection	Allison and Nevanlinna, 1952
Africans, mostly West African	74	2.7	"	Barnicot, 1950
Chinese (in London)	66	10.6	"	Barnicot, 1950
Chinese (in Malaya)	50	2.0	"	Lugg and Whyte, 1955
Japanese	295	7.1	Selection	Saldanha, 1958
Formosan "Natives"	1756	(1.8)	Crystals	Rikimaru, 1936
Malays	50	15.6	Selection	Lugg and Whyte, 1955
Tamils in Malaya	50	27.2	"	Lugg and Whyte, 1955
Bombay Indians	200	(42.5)	Solution	Sanghvi and Khanolkar, 1950
Ramah Navahoes	264	(2.0)	?Paper	Spickles (unpublished)
Cree & Beaver Indians N. Alberta	489	(2.0)	Crystals	Matson, 1940
Eskimos, Labrador	130	(41)	Paper	Sewall, 1939
Eskimos, N. Alaska	68	25.8	Selection	Present paper
Negritos, Malaya	50	18	"	Lugg, 1957
Aborigines (Sēnoi), Malaya	50	4	"	Lugg, 1957
Arabs, Assiut		(18)	Paper	Boyd and Boyd, 1937
Bantu, Kenya	208	3.8	Selection	Allison, 1951
Arabs, Kenya	63	25.4	"	Allison, 1951
Indians, Brazil	163	1.2	"	Kalmus, 1957
Welsh	203	17.24	"	Beach, 1953
Portuguese	454	24.0	"	Cunha and Abren, 1956

Parentheses indicate studies in which techniques other than selection were used.

Various compounds have been shown to be tasted by PTC-tasters and not by non-tasters, although the threshold concentration is variable (Hopkins, 1942; Harris and Kalmus, 1949; Kuhn and Zilliken, 1950; Barnicot, Harris and Kalmus, 1951). A characteristic of these chemicals was the presence of the thiourea grouping $=N-\overset{\overset{S}{\|}}{C}-$. Substitution of oxygen for sulphur removes the difference in response of PTC-tasters and non-tasters. The grouping which is specifically concerned with taste-threshold bimodality is common to a large series of anti-thyroid and goitrogenic substances (Riddle and Wybar, 1944; Astwood, Bissell and Hughes, 1945; Boyd, 1950).

Following up a possible relationship to thyroid diseases, Harris, Kalmus and Trotter (1949) reported a significantly higher incidence of non-tasters among persons with nodular goitre than normal controls; the association was not found in persons with diffuse goitre. These findings have recently been confirmed by Evans and Kitchin (1958).

In examining the overall distribution of the PTC-tasting character, then, it is worth considering whether it might be subject to environmental influence and, in particular, whether it bears any relationship to thyroid function. The first question which arises is whether any obvious correlation with extremes of climate exists. There seems, in fact, to be no such correlation. The highest and lowest frequencies of non-tasters are recorded in tropical climates (Indians, Africans, and South American Indians, respectively). At the other extreme, Eskimos have rather high frequencies of non-tasters while Lapps have rather low frequencies. The second question is whether there is any correlation with intake of iodine or goitrogenic compounds. Available data are insufficient to reach any decision on this point. It would seem to be worthwhile to investigate the PTC-tasting frequencies in populations living for long periods in iodine-deficient regions or those in which goitrogenic compounds are regularly consumed. Clements and Weshart (1956) have discussed the distribution of goitrogenic substances in some diets.

The considerable difference in PTC-tasting frequency between Eskimos and American Indians appears also in other genetically controlled characters, including urinary β-amino-*iso*butyric acid excretion (Allison, Blumberg and Gartler, 1959), haptoglobin types (Blumberg, Allison and Garry, 1959), and some blood groups (particulary the near absence of type B in Indians and its presence in Eskimos) (Corcoran, Allen, Allison and Blumberg, 1959). These observations together with linguistic

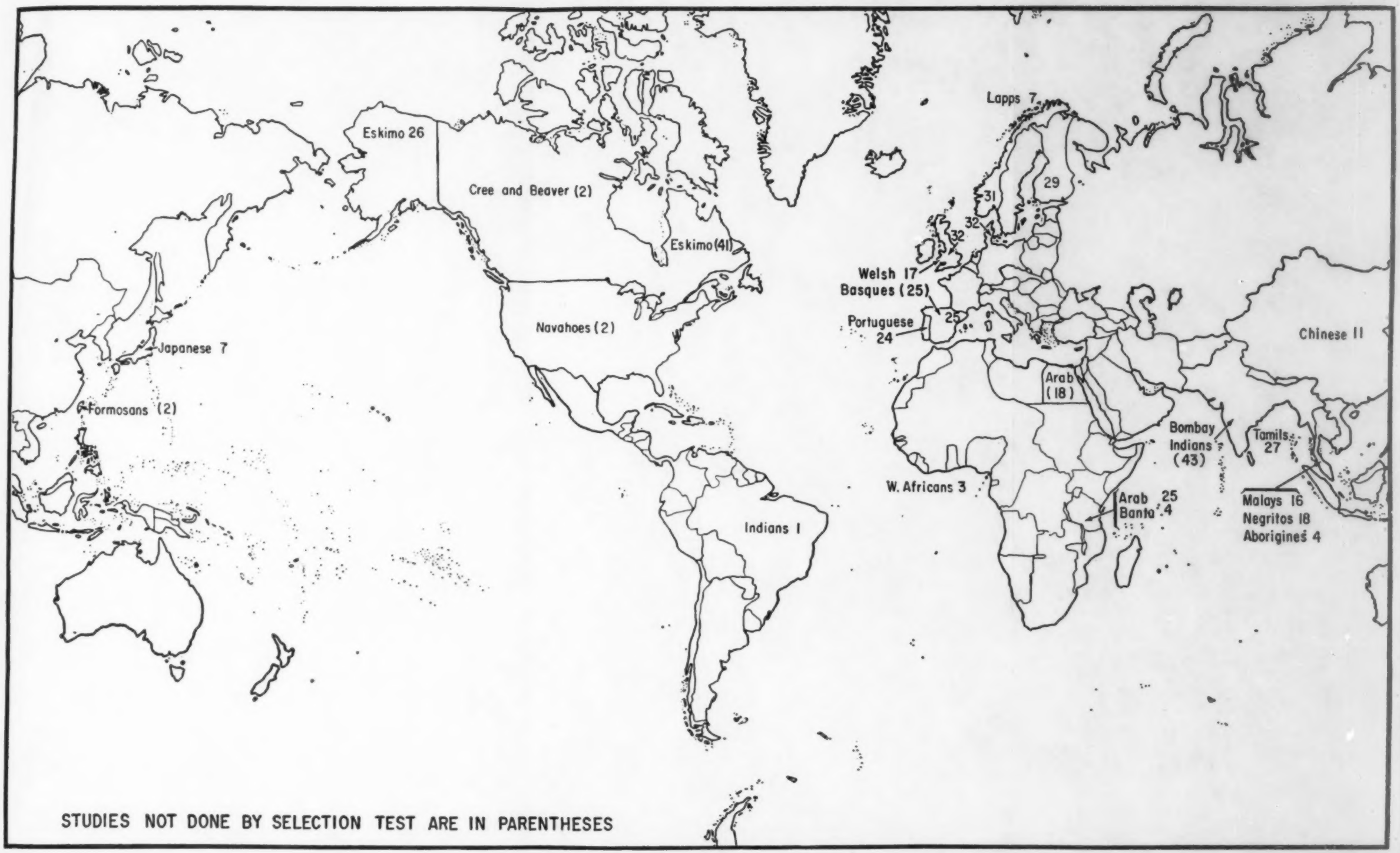

FIG. 2. THE INCIDENCE IN PERCENT OF NON-TASTERS OF PTC IN VARIOUS POPULATIONS.

and cultural differences between American Indians and Eskimos, make it improbable that the two populations are closely related racially.

SUMMARY

Using a method for determining taste thresholds for PTC, 26% of 68 Northern Alaskan Eskimos were found to be non-tasters. This is in sharp contrast to the low frequencies of non-tasters reported in American Indians.

The overall distribution of non-tasters of PTC is discussed. In view of available evidence suggesting a relationship of PTC to goitrogenic compounds and thyroid disease, it is possible that these frequencies might be subject to environmental influence. No obvious correlation with extremes of climate appears to exist, but it would seem worthwhile to investigate the possibility of a relationship to intake of iodine and goitrogenic compounds in various populations.

ACKNOWLEDGMENTS

We are indebted to various people who facilitated the field work in Alaska, in particular Mr. M. C. Brewer and Dr. J. Halvorsen, Barrow. The authors are indebted to Dr. J. Tata for his comments on the manuscript. The participation of one of us (A. C. A.) in the Alaskan investigation was made possible by a grant from the Wenner-Gren Foundation for Anthropological Research.

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BOOK REVIEWS

Handbook of Population Census Methods. Volume I. *General Aspects of a Population Census.* vi + 164 pp. Volume II. *Economic Characteristics of the Population.* vi + 79 pp. Statistical Office of the United Nations, Studies in Methods, Series F, No. 5, Rev. 1. United Nations, New York, 1958. Price not available.

The major problems of research in comparative demography are not those of method, personnel, institutional facilities, or financial support. They are, rather, the paucity of data and the selectivities in the data that do exist. Little can be done to correct the situation with reference to the past record, but the Statistical Office of the United Nations is the leader among many international groups stuggling heroically to persuade nations to collect and process more and better statistics in the future. The fundamental activity in the statistical field is the census, and here major attention is focused, particularly in the years around the end of each decade.

The Statistical Office issued a series of manuals in connection with the national censuses taken in or around 1950. These were based on the experiences of countries with censuses from 1935 to 1944. A new three-volume *Handbook of Population Census Methods* is being issued to include the international recommendations for the 1960 censuses and to utilize the experiences of the censuses taken in the years from 1945 to 1954. In addition, the discussions are recast with reference to "the problems and needs of countries having little experience in and few resources for census-taking" (Volume 1, p. iii.). The needs of the country are given priority over international comparability. Definitions of a census and an enumeration are tolerant, and many sections are presented so that they can be models for procedures. Sampling is emphasized, including the possibility of a sample survey if a complete census is not possible. Census schedules are reproduced for Canada, Ceylon, France, India, Japan, Pakistan, Panama, Senegal Territory, Tanganyika Territory, Uganda Territory, United States, and Yugoslavia.

The *Handbook* is obviously essential for those who are involved in census activities. It is a valuable document for research consumers of census data from countries with little census experience, for here is the

international model and the guide to definition and procedure. For students of international cooperation in scientific advance, it is a fascinating document.

The publication of the *Handbook of Population Census Methods* and the various preceding and associated documents is an indication of major progress in the extension of census activities, but it is an unsafe guide to the measure of that progress. The statement that 150 countries took censuses and secured data on more than two billion people in the decade from 1945 to 1954 suggests an approaching great leap forward for regional and comparative demographers. Unfortunately the two billion people include the 600 million people of China (as reported from the "census") for whom only a few figures on the sex ratio, the populations of provinces and cities, and the numbers of the minority groups have been published from a quick survey that was in large part a registration of heads of households in association with a registration of voters. If the figures on countries and populations included only those covered by reasonably complete and accurate censuses, the data from which were published, the global status would warrant little optimism. The state's role seems to require the taking of a census, or at least the statement of intent to take one. The motivations and the resources for tabulation, analysis, and publication are more restricted. The realization of this hiatus between enumeration and publication is widespread; so also is the appreciation of the qualitative deficiencies of the data that are collected and the inadequacies of the tabulations that are made. Perhaps the most significant developments with reference to the 1960 censuses are the activities of countries and international organizations oriented toward the analysis of the data that will be collected.

If further mitigation of research optimism is required, it follows from an inspection of Table 1, Volume 1, on population censuses taken in selected countries during the period from 1855 to 1957. The list would be reduced very greatly if censuses taken but completely or largely unpublished were deleted. The definition of a census in precise terms would reduce the list of countries and the frequency of censuses for the countries that remained, even if no requirement of publication were imposed. For instance, the statistical activities of the Manchus in the last few years of their reign are listed as three censuses of China; the activities of the Republic of China in 1912 and 1928 yield two censuses; the activities of the government of Communist China in 1953-1954 yields another census. Thus there were 6 censuses of China between 1905 and

1957! The listing of the initial *koseki* registration of 1872 and the registration compilations of the years from 1898 to 1918 give Japan 6 "censuses" in its precensus period. However, there are instances in which the facts are more optimistic than the list. The 1895, 1915, and 1940 censuses of Taiwan are omitted. Moreover, countries such as Korea with substantial census records are omitted entirely.

IRENE B. TAEUBER

Office of Population Research
Princeton University

The Ecology of Human Disease. By JACQUES M. MAY. xxiv + 327 pp. MD Publications, New York, 1958. $7.50.

"The concept of medical ecology formulated by Dr. May conceives disease as a convergence in time and space within the person of the patient of environmental stimuli (organic, inorganic, or sociocultural). These stimuli are a challenge which induces a tissular response, that is, disease (communicable, degenerative, or behavioral), which in its turn eventually results in ecologic adaptation and survival or in total maladjustment and death." In these words Martí-Ibáñez summarizes in his Foreword the position taken by the author, which is sufficiently in accord with Haeckel's original definition of ecology to be acceptable, and sufficiently stimulating to be a useful extension of its customary scope.

The first seven chapters explain the author's position in general and simple terms; but so simple and general that eyebrows are sure to rise at some of the omissions or over-simplifications. Of the three groups for whom the author is writing—physicians, geographers, and anthropologists—two will find little that they did not already know, and some statements that they will question. The position that *all* disease results from the interaction of external stimuli and tissue response is probably defensible from a philosophical point of view, but one may hesitate to relinquish in practice the category of disease in which disorder appears to arise from innate derangements involving, but not dependent upon, environmental conditions. It is possible that this category will progressively shrink as knowledge increases, but it seems premature to discard it at this time.

Specialists may be somewhat irritated at the casual manner in which

the author brushes aside existing knowledge in some fields; *e.g.*: "Little is known about the direct action (of climate on man)"; and "no comparative knowledge of physiology in human groups is available to this day." While an author has a right to define his terms as suits his argument, readers will not be very happy with the statement, "Culture is the sum total of the concepts and techniques that human groups use and abide by in the environment in which they are placed, in order to survive"; and there may be many protests against the statement that anthropology *includes* anatomy, craniology, archeology, and several other highly respected disciplines, with more than a hint that medicine has now been admitted. It is difficult to cite characteristics that will unequivocally assign an individual to a "race," but confusion is hardly less confounded by substituting an areal population as the classification unit. The presence of *Clonorchis*, for example, carries very strong presumptive evidence that the host has at some time been in the Far East, but whether as casual visitor or long-time resident, and therefore whether a true member of the geographic group or not, is in no way revealed.

In the remaining thirteen chapters the author has brought together a wealth of information on the incidence of disease, its geographic history, and associated environmental factors (physical, biological, sociological). He has presented it in very readable form. Undoubtedly this presentation may be called ecological, and it represents a very good first approach to an important and sizeable task; but readers will hope that ecological descriptions of the future will get down to more intimate details of the controlling factors, their relative intensities, and some quantitative expression of their interaction.

DOUGLAS H. K. LEE

Quartermaster Research & Engineering Command, Natick, Massachusetts

Blood Groups. A. E. MOURANT, Chairman of the Symposium. Brit. Med. Bull., *15*(2):89-174, May, 1959. $3.25.

Some of the leading British investigators assembled recently to discuss such subjects as blood group substances and antibodies, heredity of the blood groups, erythroblastosis fetalis, seed agglutinins, animal blood groups, blood groups and disease, etc. The papers have now been collected in a special issue of the British Medical Bulletin. The bulletin

constitutes in fact a monograph on recent advances in blood grouping and as such is indispensable to all concerned with this subject.

In general, the work presented is on a high plane and can be accepted without reservation. However, in this publication as in other recent books on the subject published in England, there is a tendency to emphasize the contribution of British investigators. In some cases this has been carried to an extreme, with two unfortunate results. Firstly, many of the original observations had been made by scientists in the United States and later were confirmed by workers in England, but the original work is not cited, even though in many instances it was more complete. As examples may be mentioned Wiener's pioneering work on the heredity of the Rh-Hr blood types, and his early studies on variants of the Rh-Hr factors especially the **Rh$_o$** variants. There has been a tendency to credit such work incorrectly to British workers. For example, a recent textbook in hematology incorrectly credits Fisher, a biometrician and *not* a serologist, with the discovery of the various Rh factors and their heredity, while Stratton is incorrectly credited with the discovery of **Rh$_o$** variants, even though his only contribution was to coin the alternative fallacious symbol D^u. Secondly, no reference is made to the work of other leading investigators whose findings and conclusions are at variance with certain views held by British investigators regarding basic questions in the field. This one-sided presentation by British authors limits the usefulness of the symposium. The chief serious fault of the presentations is that they give only a single point of view, and fail to discuss or even admit the existence of any evidence for any alternative viewpoint.

The unfortunate effects of the failure to consider the contributions of other investigators is illustrated by the vast amount of effort and time that British workers have wasted on blood groups and disease, a topic to which considerable space is devoted in the monograph. Of course, the clinical importance of blood groups in erythroblastosis fetalis is now universally recognized, following the pioneering work of Levine and his associates in the United States. Here a definite mechanism has been discovered, namely, isosensitization by pregnancy (or transfusion), with subsequent transplacental transfer of maternal isoantibodies to the fetus, resulting in hemolytic disease. This correct basic concept has not only served to explain the pathogenesis of erythroblastosis fetalis, but also has led to a rational treatment. (Here again, the otherwise excellent articles on erythroblastosis fetalis in the Bulletin fail to mention the pioneering work of American investigators.)

On the other hand, no one has ever been able to suggest any mechanism by which, or any reason why a *group O* person should be more susceptible to duodenal ulcer, or a *group A* person to gastric carcinoma or fractured femur, etc., any more than why it should matter whether the iris of one's eyes is colored brown, gray, or blue, so long as it is pigmented. The answer, of course, is that "the hardest things to explain are those which aren't true." No mention is made of the fact that this line of investigation was popular more than three decades ago, when the subject was young and knowledge and understanding limited, but was abandoned when it was realized that such studies lack any sound rationale and have no direction. It seems that the modern more sophisticated approach to the fallacious problem of blood groups and disease originated from a pronouncement made by a biometrician that "no gene is neutral in natural selection." This proclamation was taken to heart by many investigators, although no one has ever disproved the existence of neutral genes. The effect of this edict has been to stimulate an endless series of studies on A-B-O blood group distribution in such diseases as peptic ulcer, carcinoma of the lungs and stomach, pituitary adenoma, pernicious anemia, fracture of the femur, dental caries, etc. And this represents barely a beginning, since nothing or hardly anything has yet been done regarding the M-N-S types, Rh-Hr types, P types, eye color, hair color, etc., which are gene determined, and, therefore, according to the biometricians, are not neutral in selection.

One of the many fallacies of the studies on blood groups and disease is that the various series of patients are collected from case histories over a period of many years from a number of different hospitals, while the so-called controls are generally a series of consecutive blood donors assembled in a brief period, so that the two series are not comparable. Moreover, when the A-B-O blood groups distribution is studied in many different diseases, some of the series are bound by chance to show deviations at the conventional level of so-called statistical significance. Finally, there is always the possibility of the introduction of some sort of bias into such investigations. For example, Billington failed to confirm the supposed higher incidence of carcinoma of the stomach among *group A* persons but reported instead that the distribution of the groups appeared to differ according to whether the lesion was in the prepyloric area, the body of the stomach, or the cardiac area. This led Wiener to inquire (Letter to the Editor, Lancet, Dec. 22, 1956) whether "in assigning the cancer to one or the other area, the investigator was

subconsciously biased, in borderline cases, by his prior knowledge of the patient's blood group." Billington responded, "I admit I am unable to exclude the possibility that the figures in relation to the site of gastric carcinoma might have been influenced in borderline cases by knowledge of the patient's blood group." One wonders, why in the review on blood groups and disease in the Bulletin no reference is made to this very important fact. Similarly, the Bulletin cites the first study on blood groups in pituitary adenoma but fails to mention the later more critical paper refuting the original report. With regard to the excess of *group O patients* among individuals with duodenal ulcer, one must bear in mind that the cases were culled from hospital records. One of the most common causes for hospital admissions in such cases is hemorrhage, and in emergencies such patients are given group O blood when there is not enough time for grouping and matching tests. This could have caused confusion regarding the patient's true blood group, and such cases might have been classified erroneously as group O, thus accounting for the bias.

In summary, while the issue of the British Medical Bulletin devoted to the Blood Groups is indispensable for workers in the field, it cannot be recommended for non-specialists because of the parochial nature of its presentation and some misinformation it contains.

A. S. WIENER

64 Rutland Road,
Brooklyn 25, N. Y.

Manual de Antropología Física. By JUAN COMAS. 698 pp., 114 figs., 98 tables. Fondo de Cultura Económica, México 12, D. F., 1957. No price indicated.

For a long time there has been a great need for a textbook of physical anthropology in Spanish or Portuguese, the languages spoken in Latin America. Comas' book attempts to supply this need.

It starts with a chapter on Generalities (62 pp.); then come: Origin and Evolution of Man (38 pp.); Heredity (74 pp.); Growth (64 pp.); Somatology (57 pp.); Biotypology (42 pp.); Craniology and Osteology (71 pp.); Paleoanthropology (104 pp.); Racial Systematics (57 pp.); and Utilization and Teaching of Physical Anthropology (41 pp.). There are also seven appendices (23 pp.), a good bibliography and several indexes.

The book is well written and the author is to be congratulated for the emphasis on the "modern approach" in physical anthropology. Another good feature is the abundance of references in the footnotes and in the bibliography at the end of the volume. The printing is excellent, and there are few typographical errors.

In a work of such a wide coverage, some mistakes and omissions are inevitable. Some of them will be discussed here. But it should be clear at the outset that the book, even in the present form, is to be highly recommended to all persons interested in these problems.

Our observations can be summarized as follows:

a) The chapter on Generalities is very good, especially the detailed historical section.

b) Chapter 2 presents an informative review of the concepts about the origin of life, organic evolution and, at the end, of human evolution. As this latter subject is discussed at length in chapter 8 (pages 497-525), it seems that it would be better to discuss only organic evolution in chapter 2, leaving all the material concerned with human evolution for discussion in chapter 8.

c) Being a geneticist, the reviewer was especially interested in the chapter on Heredity. In the beginning of the chapter the difficulties encountered in the study of human genetics are stressed, but not a single word is given about the advantages of the human material. Mendel's first law is presented in reference to rats (why?). A little more emphasis should be placed on the notion of the separation of genes, as opposed to the old idea of blood mixture.

Pages 127-130 include special, though not really important, cases of modifications of Mendelian ratios. This part could be omitted in a book of this nature. Sex-linkage inheritance is exemplified first in *Drosophila*, and then in man (hemophilia).

On page 134 there is a list of human normal characteristics (taken from Guyénot, 1942, *L'hérédité*), stated to be inherited in a simple way. However, in the great majority of the cases their hereditary mechanisms have not yet been completely worked out and their inheritance is probably due to several genes (for example: eye color, hair shape, stature; as to the cephalic index, it was shown that identical indices might result from quite different conformations of various cranial bones, which in turn might be due to entirely different genes).

On pages 143-146 he assumes that all geneticists are advocates of Mutationism. Actually, the great majority of them are neo-darwinists.

On page 147 he says that Simpson does not consider mutations as an important factor in evolution. Being a neo-darwinist, Simpson does consider mutations important, since they will contribute to the variation upon which selection will act.

The great omission in this chapter concerns the fundamental principle upon which all population genetics is based: the Hardy-Weinberg law.

d) The chapter on Growth contains a critical appraisal of the indices and measures which are being used in these studies. The value of the comparative material presented in the tables of this chapter would be greatly increased if the author had included the number of individuals studied in each series. As the tables stand now, it is difficult to evaluate the significance of the differences presented.

e) It would be better to include the section about cranial sutures (in chapter 7) after the description of the craniometric points.

f) In chapter 8, the Hylobatidae are considered as a family on page 440, but on page 436 they are presented as a sub-family of the Pongidae. On page 491 the author says "as we have already seen when dealing with racial systematics"—but the chapter on Raciology is *after*, not before chapter 8. And, it is believed, the section about the proofs of human evolution (page 522) should be placed before this subject is discussed (page 497).

g) The chapter on Racial Systematics would be greatly improved by the addition of figures presenting the distinguishing features of individuals from the several groups discussed, as well as some maps of their distribution. The section on Demography is so small (pages 582-583) that it is hardly of any value.

h) In the first part of chapter 10 (Utilization and teaching of Physical Anthropology), the author seems to consider as synonyms the terms "physical anthropology" and "anthropometry," a view which is contradicted by the very nature of his book!

All the criticisms involved minor points or rearrangement of the materials presented. Comas has written a readable, up-to-date review of the fundamental concepts of physical anthropology. It is expected that his book will enhance significantly the progress of this science in Latin America.

FRANCISCO M. SALZANO

Instituto de Ciências Naturais,
Universidade do Rio Grande do Sul,
Pôrto Alegre, Brazil

Recherches sur L'Anthropologie des Françaises. By SUZANNE DE FELICE. 316 pp. Masson, Paris, 1958. No price indicated.

In this thorough and careful monograph, Dr. de Felice has attempted to provide us with the same sort of somatological information concerning French women as the so-called older school of physical anthropologists have given us concerning the adult male sector of the population of many tribes and nations. It has the virtues and deficiencies inherent in this approach to anthropological knowledge, as well as some virtues of its own. We have far too little precise data on women, and any addition is valuable and interesting. Fortunately, a few other such studies exist, and one of the most useful aspects of Dr. de Felice's work is her comparison of the French with other European female groups which have been examined. The similarity, in size and proportions, between the means of all these groups, ranging from Slovenes and Esthonians to Norwegians and Swiss, is remarkable. Differences, in the frequency of blondness of eyes, hair and skin are, of course, demonstrated, and from other sources we know that differences in such genetic characteristics as blood-type frequencies are many times greater.

But the volume lacks data on matters such as this, as on other genetic characteristics. Nor is there any information concerning physiology, or growth, or aging. The group studied consists of 140 women in Paris, who were willing to submit to the author's examination, in good health and between the ages of 20 and 48 years. The ancestors of the subjects are said to have come from all different parts of France, as one might expect in a capital city, but the proportions derived from the various sections of the country are not stated in any quantitative manner. Only one-quarter of the women were mothers and the greater number were nurses or student nurses. One may doubt whether such a sample is either random or properly stratified to represent the women of France. Obtaining an adequate sample of women which is demonstrably representative of an ethnic group for anthropological examination in the nude is rendered difficult if not simply impossible by the inhibitions of our culture.

The author is to be commended for the complete frankness with which she discusses her difficulties and uncertainties, for the care with which she has described her techniques, and for the precision and clarity with which she has presented not only her own data, but the comparative material which she has included. Her discussion of female characteristics is particularly valuable and she has devised an index (p. 69) to express

the degree of separation of the breasts. In the opinion of this reviewer, however, a greater number of visual observations could well have been included. It would doubtless be out of the question to record, correctly, the degree of curliness of the hair, even of females who were willing to submit to an examination of this sort, but hair texture might have been mentioned. The shape of the nose should, in a study of this nature, have been more adequately described. The use of skin-fold calipers would have assisted in the description of adiposity. Eyebrows are not even mentioned.

Among items of interest in this study are the lack of any significant correlation between stature and cephalic index, the lack of greying in pubic hair, the lack of consistent trends in the age-differences recorded, (*n. b.*, on pages 202-205 the younger and older age-groups are labelled in reverse, by misprints at the top of each column), and the almost total absence of red hair among the Frenchwomen included in the series studied. For the body as a whole, weight and the position of the breasts appear to show the greatest degree of variability; for the face, the shape of the lips and of the nose are most variable. On the whole, however, standard deviations are lower than those of the other European groups with which this French series is compared. One may still doubt, however, that the French are in fact more homogeneous biologically than other European nationalities. Despite its lack of theoretical conclusions, this monograph should serve as a most useful source of information concerning the physique of European females of the present generation.

FREDERICK S. HULSE

University of Arizona
Tucson, Arizona

Primates: Paléontologie Humaine. By JEAN PIVETEAU. *Traité de Paléontologie,* Tome 7. Pp. 675. Illustrations 639. Paris, Masson & Cie., 1957. Francs 12,800.

This is the seventh and final volume of the magnificent Traité de Paléontologie edited by Professor Jean Piveteau, the present volume being entirely the work of Piveteau. It triumphantly and fittingly caps the preceding volumes. Piveteau's *Primates* is by far the best and most exhaustive work on the paleontology of the primates available in any

language, and it will serve as an indispensable work of reference for many years. The text is beautifully clearly written, and the 639 illustrations are a veritable feast, including an extra dividend of 8 plates, 4 of them in color. The bibliographies following each chapter are excellent, and there is a good index.

Although this is a work on human paleontology, it covers the paleontology of all non-human primates, the first third of the book being devoted to them. The remainder of the book deals with the process of hominization as revealed by the paleontological record. The reader is not far into the book before he discovers that what he is reading is much more than a human paleontology. It is that, but also a great deal more, for this is a work on the origin and evolution of man in which not only is virtually every find described (there are some omissions) and classified, but its relation to other forms is clearly set out, and all to the end of throwing light upon the problem of the manner in which man came to be as we find him today. It is all remarkably well done and extremely readable to boot. It is a pity that the price of the book will make individual ownership of it a rarity. Most readers will have to borrow it from a library. Somehow in the English-speaking world we manage to produce books much less expensively than the French and the Germans. I wonder why?

ASHLEY MONTAGU

Cherry Hill Road,
Princeton, N. J.

Behavior and Evolution. Edited by ANNE ROE and GEORGE GAYLORD SIMPSON. 557 pp. Yale University Press. New Haven, 1958. $10.00.

Evolution is a general theory of biology. It represents a synthesis of the facts of behavior of organisms as well as those of structure (morphology) and organ function (physiology), for these three aspects are inseparable. The desirability of an interdisciplinary appraisal of their bearing on evolution led to two symposia and, eventually, to the present book.

The relationship between evolution and behavior turns out to be a complex one. Since our knowledge in both fields is still very imperfect, the different participants are, understandably, unable to present a

definitive position. Bullock faces the issue squarely when he says that physiological mechanisms cannot account for observed behavior: "Hope lies in the discovery of new parameters of neuronal systems." The aims of the volume are more modest: the localization of facts, theories and techniques in each of the pertinent disciplines that may be applicable in other fields. The bulk of the book is perhaps best considered as a documentation of the intricate relationship between evolution and behavior.

The complexity of the subject is indicated when behavior is approached from the facts of biology. The comparative ethologists point out that one can use the data from comparative behavior in the same way as one uses the findings of comparative anatomy and physiology. Mayr for instance mentions the reclassification of finchlike birds on the basis of their behavior. The same conclusion was reached independently on the basis of morphological criteria. On the other hand behavior does not always correlate with structure as expected. For instance the cat has the retinal and cerebral structures (in its lateral geniculate body) that are always associated with color vision, but the cat is totally color blind. The same complexity exists for the physiological mechanisms. Beach, after reviewing the endocrinological correlates of sexual behavior, concludes that the specific nature of the hormone is only part of the mechanism underlying sexual behavior in the male animal. Evolution in this kind of behavior is more likely attributed to changes in "physiological systems upon which hormones tend to exert their effects. A prime candidate for intensive consideration and study is the nervous system."

The student of behavior, with his "functional" approach, is likely to be interested in ontogenesis and, in general, in adaptation of organisms to immediate conditions rather than in the long-range adaptations associated with phylogenesis. The functional concepts when applied to the evolution of behavior may become awkward or vacuous. Emerson, for instance, speaks of evolution occurring in the direction of improved homeostasis. This position, a little later on, forces him to indicate that "Homeostasis often is the maintenance of unbalance, disequilibrium and asymmetry, as well as the reverse" (p. 323). Such usage of physiological concepts does not add to a meaningful description and analysis of behavior.

The concepts used in relating behavior to evolution are in need of clarification. Pittendrigh in a very fine paper performs this function for the concepts of adaptation and natural selection. He points out

"that adaptation is a relative matter in many senses; that it cannot be discussed in absolute terms; and specifically that adaptation cannot be recognized with a criterion of necessity-for-viability."

The chapters dealing with behavior at the social and cultural level are perforce the least satisfying parts of the book. As Huxley remarks, "Through human culture, behavior has reached a supraorganismal level" (p. 454). The biological theory of evolution does not seem to be very relevant to behavior at this level. Yet the book, when considered in its entirety, does present a valuable range of documentation of the relationship between evolution and behavior.

The volume includes twenty-three chapters collected into five major areas. The editors have supplied appropriate and brief introductions to each part of the book. Two of the chapters were written by Simpson especially for this volume. The first article is a rapid and clear review of theories of evolution. In the epilogue the author attempts to gather together into a meaningful whole the diverse strands of thought and of fact found throughout the book.

The articles vary greatly in the demands that they make on the reader. Articles such as Simpson's discussion of theories of evolution or Bullock's treatement of *Evolution of Neurophysiological Mechanisms* can be profitably read by biologists or psychologists not trained in these areas. The same applies to most of the chapters on behavior. Other articles, however, can be fully appreciated only by specialists in the pertinent areas. For instance Pribam's article on the *Comparative Neurology and the Evolution of Behavior* is difficult going for anyone but the specialist in neurology.

EDWARD C. STEWART
SAUL B. BARBER

Lehigh University
Bethlehem, Pennsylvania

Mind and Matter. By E. SCHRÖDINGER. 104 pp. Cambridge University Press, 1958. $2.75.

This small book written by an outstanding physicist deals in a few pages with vast biological and psycho-physiological problems. In the first chapter (15 pages) the author considers consciousness, ethics, evolution and nationalism. Problems of evolution, particularly in how

far the labors and strivings of the individual can be utilized for the development of the species, are discussed in the second chapter, which ends in some proposals for social reform in the machine age. The fourth chapter (17 pages) is concerned with the mind. For the physiological aspects of this problem Schrödinger quotes Sherrington extensively, but it seems strange to this reviewer to base one's discussion of this matter on Sherrington's experiments published in 1906 in spite of the enormous growth of neurophysiological knowledge in the last decades. Under the title "The Mystery of the Sensual Qualities" some remarks on the role of perception in science and the relation between physiological events and sensation and perception are made. This reviewer failed to see any notable advance over the ideas expressed by du Bois-Raymond in a famous oration in 1872. The book is apparently translated from German. Some sentences make no sense ("Now in man something is, so it seems, on the way that is not infrequent").

E. GELLHORN

2 Fellowship Circle
Santa Barbara, California

BOOK NOTICES

COMMEMORATION OF THE CENTENNIAL OF THE PUBLICATION OF *The Origin of Species* BY CHARLES DARWIN. Proc. Amer. Philos. Soc., Vol. 103, No. 2. The American Philosophical Society, Philadelphia, 1959, $1.00. A group of outstanding investigators assembled at the Annual Meeting of the Society (April 1959) to reexamine Darwin's work and influence, with special reference to the theory of evolution and closely related problems (variation, genetic and non-genetic; hybridization; isolation; the nature of the fossil record).

THE MOLECULAR BASIS OF EVOLUTION. By Christian B. Anfinsen. xiii + 228 pp. Wiley, New York, 1959. $7.00. "The writing of this book has been stimulated by the excitement and promise of contemporary protein chemistry and genetics and by the possibilities of integration of these fields toward a greater understanding of the fundamental forces underlying the evolutionary process."

STATISTICAL METHODS IN BIOLOGY. By Norman T. J. Bailey. ix + 199 pp. Wiley, New York, 1959. $4.50. Designed to provide workers in the biological and medical sciences with an elementary account of the chief statistical methods. Contains useful "Notes on computing and calculating machines," and, as an appendix, a Summary of Statistical Formulae to be used as a quick reference guide.

EVOLUTION OF NERVOUS CONTROL FROM PRIMITIVE ORGANISMS TO MAN. Edited by Allan D. Bass. vii + 240 pp. The American Association for the Advancement of Science, Wash., D. C., 1959. $5.00. The problem is approached from the viewpoint of a botanist, an embryologist, a neurologist, a physiologist, a psychologist and a psychiatrist. In its totality, "this book portrays the impact of the evolutionary process upon the brain" (Bernard B. Brodie's Preface).

PRINCIPLES OF GENERAL PHYSIOLOGY: VOL. I. The Physico-Chemical Background. By L. E. Bayliss. xiii + 520 pp. Longmans, Green and Co., N. Y., 1959. $11.50. The "Principles," a classic in its field, has been given loving care by the Bayliss family for half a century. The first edition by Sir William Bayliss came out in 1915. The present fifth edition, retaining the traditional excellence, is the work of Sir William's son.

EXPERIMENTATION IN MAN. By Henry K. Beecher. 80 pp. Thomas, Springfield, Illinois, 1959. $3.50. Concerned with the ethical and legal aspects of human experimentation. Sets down views, concepts, and "rules," so that the investigator troubled by a given problem can find references to past thinking on the subject.

PHYSIOLOGY AND BIOCHEMISTRY. By George H. Bell, J. Norman Davidson, and

Harold Scarborough. xi + 1065 pp. Williams and Wilkins, Baltimore, 1959. $12.50. Fourth edition in a span of less than one decade. Published also in Italian and Spanish (1959). The fact that a physiologist, a biochemist and a clinician collaborated in producing this volume may have something to do with the balanced presentation of the material (and the success on the book market).

HISTORY OF BIOLOGY. By F. S. Bodenheimer. 465 pp. Dawson, London, 1958. $5.88. A boon to the student and teacher of the subject but not a textbook. Instead of a General Introduction, Part I consists of " Parerga and Paralipomena " (accessories and matters usually left out). Part II is a short factual history of biology. Part III consists of Sources from the History of Science—brief selections from 130 authors.

ISAGOGAE BREVES (A SHORT INTRODUCTION TO ANATOMY). By Jacopo Brengario da Carpi (ca. 1460-1530). Translated, introduced and annotated by L. R. Lind with anatomical notes by Paul G. Roofe. xi + 228 pp. The University of Chicago Press, Chicago, 1959. $5.00. Provides, in the words of Horace W. Magoun, a valuable transition between Charles Singer's translation of Mundinus' *Anatomy*, representing the medieval period, and Lind's earlier translation of the *Epitome* of Vesalius, representing the high renaissance.

PSYCHOPHARMACOLOGY: PROBLEMS IN EVALUATION. Edited by J. O. Cole and R. W. Gerard. viii + 662 pp. The National Academy of Sciences, Wash., D. C., 1959. $6.50. The subtitle should continue: Evaluation of Pharmacotherapy in Mental Illness. Focused on the assessment of the present (1956) state of knowledge by scientists engaged in research related to psychopharmacology.

REPORT OF THE MEDICAL RESEARCH COUNCIL FOR THE YEAR 1956-1957. By the Committee of Privy Council for Medical Research. Her Majesty's Stationery Office, London (available from British Information Services, New York), 1958. $1.82. " Genetics of Eye Disease " (pp. 50-56) is discussed in the section concerned with general trends in medical research. There is an informative summary of the work of numerous research institutes—the best available source of information on current biomedical research in Great Britain—and a classified list of publications.

ELEMENTARY STATISTICS WITH APPLICATIONS IN MEDICINE AND THE BIOLOGICAL SCIENCES. By Frederick E. Croxton. 376 pp. Dover Publications, New York, 1959. $1.95. A reprint (first edition, 1953) of a handy manual.

THE LIFE AND LETTERS OF CHARLES DARWIN. Edited by his son, Francis Darwin. Volume 1—xxii + 588 pp. Volume 2—562 pp. Basic Books, New York, 1959. Set $10.00. A reissue, with a foreword by George Gaylord Simpson.

ANTROPOMETRIA DA TRIBO CACONGA. By J. H. Santos David. 114 pp. Companhia de Diamantes de Angola, Publicações Culturais No. 36, Lisboa, 1958.

No price indicated. The author is a physician associated with the Diamond Company of Angola (Portuguese West Africa). He wrote about blood groups (1949) and studied the anthropometric characteristics of the natives of the region of Lunde and Songo (1955). This is a continuation of his anthropometric (largely osteometric) researches, devoted to the Caconga tribe.

TEN STEPS INTO SPACE. x + 202 pp. Monograph No. 6. Franklin Institute, Philadelphia, 1958. $4.00. A series of lectures sponsored by the Institute in March-May, 1958. D. C. Simons spoke on "Space Medicine—The Human Body in Space" (pp. 161-178). The problem is taken up, briefly, also, in I. M. Levitt's "Satellites and Travel in the Future."

PSYCHOLOGY AND HUMAN PERFORMANCE. By Robert M. Gagne and Edwin A. Fleishman. xiii + 493 pp. Holt, New York, 1959. $7.25. An introductory survey of the basic components of behavior, treating psychology as experimental science, with heavy reliance on graphic presentation of facts and emphasis on the interaction of the individual with his environment.

MEDICINE AND ANTHROPOLOGY. By Iago Galdston. 165 pp. The New York Academy of Medicine Lectures to the Laity, No. XXI. International Universities Press, New York, 1959. $3.00. A more precise title for this readable and useful collection of 6 lectures would be "Medicine and *Cultural* Anthropology" dealing as it does with such topics as acculturation, magical practices, and relations between medicine and humanities.

PHYSIOLOGICAL BASES OF PSYCHIATRY. Edited by Horsley Gantt, M. D. xiii + 344 pp. Thomas, Springfield, Illinois, 1958. $10.50. Articles presented at the 25th Anniversary of the Pavlovian Laboratory in Baltimore and at the first meeting of the Pavlovian Society held at the Behavior Farm Laboratory (H. S. Liddell, director). A bibliography of publications from the Pavlovian Laboratory of the Phipps Psychiatric Clinic, Johns Hopkins University, is usefully appended.

THE INEFFECTIVE SOLDIER: LESSONS FOR MANAGEMENT AND THE NATION. 1. The Lost Divisions (xx + 225 pp.) 2. Breakdown and Recovery (xvii + 284 pp.) 3. Patterns of Performance (xix + 340 pp.). By Eli Ginzberg and coworkers. Columbia University Press, New York, 1959. $6.00 per volume. Concerned with the personality and performance of young Americans who were rejected for military service during the second World War or who were prematurely discharged because they were judged to be deficient in the qualities that make good soldiers.

ANATOMY OF THE HUMAN BODY. By Henry Gray. 27th edition. Edited by Charles Mayo Goss. 1458 pp. Lea and Febiger, Philadelphia, 1959. $17.50. Few textbooks indeed, live to be one hundred years young: Here is an exception, the centennial edition of the justly famous *Gray's Anatomy*! The first American edition was brought out by Blanchard and Lea in Philadelphia in 1859, a year following the publication of the first English edition in London.

THE BASES OF SPEECH. By Giles Wilkeson Gray and Claude Merton Wise. xiii + 562 pp. Harper, New York, 1959. $6.00. A broad treatment of the nature and function of speech, including the biological (neurological, physiological) bases of speech.

PEDIATRIC METHODS AND STANDARDS. Edited by Fred H. Harvie. v + 330 pp. Lea and Febiger, Philadelphia, 1958. $4.50. The third edition (the 1951 and 1956 editions were intended only for local use) of a pocketsize *vade mecum* prepared by the staff of the Department of Pediatrics, School of Medicine, University of Philadelphia. Of special interest may be the chapters on Growth and Development (pp. 9-39).

THE INFLUENCE OF LIVING AND WORKING CONDITIONS ON HEALTH. International Medical Association for the Study of Living Conditions and Health, Vienna. xvi + 607 pp. With summaries of communications in English, French, German, Russian and Spanish. Proceedings of a conference, held at Cannes, (France) 27-29 September 1957. The three central topics were: role of nutrition in disease, effects of work on physical and mental health, and late effects of ionising radiation on man's health.

THE ONSET OF STUTTERING. By Wendell Johnson and Associates. ix + 276 pp. University of Minnesota Press, Minneapolis, 1959. $5.00. A detailed report of a series of three investigations, conducted between 1939 and 1957. A total of 246 children who stuttered, an equal number of controls, and the children's parents were studied by means of interviews, clinical observations, and test procedures.

ABNORMAL HEMOGLOBINS. By J. H. P. Jonxis and T. H. J. Huisman. 39 pp. Thomas, Springfield, Illinois, 1958. $2.00. The full-length title of this small publication is *Manual on Techniques for Studying Abnormal Hemoglobins*. "The question of the geographical distribution of different normal and aberrant forms of haemoglobin is, like that of the blood groups, of the greatest interest to physical anthropologists in its bearing on the interrelationships of different elements of the human population."

RESPIRATORY PHYSIOLOGY AND ITS CLINICAL APPLICATION. By John H. Knowles. ix + 256 pp. Harvard University Press, Cambridge, 1959. $5.25. Vital capacity is one of the few items of "quantitative functional anatomy" that has been used by physical anthropologists. The present volume provides a readable introduction to the study of lung volumes and to many other problems of respiratory physiology and pathology.

MALADIES HÉRÉDITAIRES DU MÉTABOLISME CHEZ L'ENFANT. By Maurice Lamy, Pierre Royer and Jean Frézal. 259 pp. Masson, Paris, 1959. 3,600 fr. The authors discuss in detail the inherited metabolic disorders of the child, a field in which substantial progress has been made in the last decade due to the pooling of the resources of biochemists, geneticists and clinicians.

ALCOHOL IN ITALIAN CULTURE. By Giorgio Lolli, Emilio Serianni, Grace M. Golder and P. Luzzatto-Fegiz. xv + 140 pp. The Free Press (and Yale

Center of Alcohol Studies), 1958, Glencoe, Illinois. $4.00. "For Italians drinking is a part of eating, even a form of eating, for wine is a food." This set of cultural traditions is considered at least partly responsible for their relative sobriety.

EXPERIMENTAL DESIGN IN PSYCHOLOGY AND THE MEDICAL SCIENCES. By A. E. Maxwell. 147 pp. Wiley, New York, 1958. $3.75. The material presents the content of lectures given to postgraduate students at the Institute of Psychiatry (Maudsley Hospital), University of London. The most frequently applicable experimental designs are presented in simple language using a minimum of mathematical terminology.

BIOCHEMISTRY AND THE CENTRAL NERVOUS SYSTEM. By Henry McIllwain. vii + 288 pp. Little, Brown, Boston, 1959. $10.00. The need for a second edition in a short span of 4 years and the fact that a quarter of the work quoted was published during this period bears eloquent witness to the rapid development of this field of inquiry.

JOSEF BROŽEK

Lehigh University
Bethlehem, Pennsylvania

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JOSEF BROŽEK

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INFORMATION FOR CONTRIBUTORS

HUMAN BIOLOGY, a record of research, is a quarterly journal devoted to the subject its name implies. It publishes original articles dealing with human genetics, development, growth, reproduction and aging, functional anatomy, bio-anthropology, human ecology, population dynamics, etc.

The original manuscripts, typed double-spaced on one side of 8½ x 11 inch paper in complete and finished form precisely as they are to appear, should be sent—packed flat—to the editor, Dr. Gabriel Lasker, Wayne State University College of Medicine, 1401 Rivard Street, Detroit 7, Michigan. It is desirable that a second copy be included in order to expedite prompt consideration, and that an additional carbon copy and copies of all illustrations should be retained by the author.

Where possible, illustrations should be made for reproduction as line engravings, hence drawn in India ink as boldly as possible. Lettering must remain legible after figures are reduced to fit on 4½ x 6½ inch pages (letters 1½ to 2 mm high after reduction are adequate). Figures should be numbered consecutively with Arabic numerals. Tables should be numbered independently from 1 up, and both figures and tables should have captions. When the amount of tabular and illustrative material is judged to be excessive or unusually expensive, authors may be requested to pay the excess cost. Galley proofs will be sent to the author and must be returned promptly; when the author makes substantial departures from copy, the cost will be charged to him. Three copies of an abstract (not to exceed 225 words) should be submitted when the proof is returned. One will be sent to the editor of *Biological Abstracts*.

References in the text to the literature should be made by using the author's name followed by the year of publication: "Studies of Garn and Saalberg (1953) . . ." At the end of the article, under the heading "LITERATURE CITED," full references with titles and inclusive page references should appear (double spaced) in alphabetical order of the authors' names: "GARN, S. M. AND J. H. SAALBERG 1953 Sex and age differences in the composition of the adult leg. Human Biol., *25:* 144-153."

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a record of research

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